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REMEDIAL INVESTIGATION PLAN

903 Pad, Mound, and East Trenches Areas

PHASE II - SAMPLING PLAN

U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden Colorado

June 30, 1988

Volume I

ROCKWELL INTERNATIONAL
Aerospace Operations
Rocky Flats Plant

DRAFT

REMEDIAL INVESTIGATION

PHASE II SAMPLING PLAN

903 PAD, MOUND, AND EAST TRENCHES AREAS

ROCKY FLATS PLANT

GOLDEN, COLORADO

JUNE 30, 1988

Prepared for

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Date 4-3-91

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1 0 INTRODUCTION

This document presents the work plan for Phase II remedial investigations at the 903 Pad, Mound and East Trenches Areas at the Rocky Flats Plant This work is part of a comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress at the Rocky Flats Plant These investigations are pursuant to the U S Department of Energy (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) and a Compliance Agreement between DOE, the U S Environmental Protection Agency (EPA) and the State of Colorado Department of Health (CDH) dated July 31, 1986 The Agreement addresses hazardous and radioactive mixed waste management at the Rocky Flats Plant The program developed by DOE, EPA, and CDH in response to the Agreement addresses RCRA and CERCLA issues and has been integrated with CEARP investigations

1 1 COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

The Comprehensive Environmental Assessment and Response Program (CEARP) is designed to investigate and clean up contaminated sites at DOE facilities CEARP is being implemented in five phases CEARP Phase 1 (Installation Assessment) includes preliminary assessments and site inspections to evaluate compliance with environmental laws and ascertain the magnitude of potential environmental concerns CEARP Phase 2 (Monitoring Plans and Remedial Investigations) completes the environmental evaluation of potential environmental concerns identified in CEARP Phase 1 Phase 2 includes planning and implementing sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant migration pathways CEARP Phase 3 (Feasibility Studies) evaluates remedial alternatives and develops remedial action plans to mitigate environmental problems identified as needing correction in CEARP Phase 2 CEARP Phase 4 (Remedial Design/Remedial Action) includes design and implementation of site-specific remedial actions selected on the basis of CEARP Phase 3 feasibility studies CEARP Phase 5 (Compliance and Verification) implements monitoring and performance assessments of remedial actions, and verifies and documents the adequacy of remedial actions carried out under CEARP Phase 4

CEARP Phase 1 has already been completed at Rocky Flats Plant, and CEARP Phases 2 and 3 are currently in progress for priority sites at Rocky Flats Plant A draft final CEARP Phase 2 remedial investigation report for the high priority sites (881 Hillside Area) has been prepared, and a draft feasibility study for the high priority sites has already been completed CEARP Phase 4 remedial design is being initiated, and remedial action is being planned for the high priority sites A CEARP Phase 2 preliminary remedial investigation report has been completed for all other priority sites (903 Pad, Mound, East Trenches Areas), and a CEARP Phase 3 feasibility study is in progress at these sites Draft plans for remedial investigations and feasibility studies at all other Rocky Flats Plant sites (non priority sites) have also been completed

CEARP Phase 2 consists of CEARP Phase 2a, Monitoring Plans, and CEARP Phase 2b, Remedial Investigations CEARP uses a three-tiered approach in preparing monitoring plans the CEARP Generic Monitoring Plan (CGMP, DOE, 1986a), the Installation Generic Monitoring Plan (IGMP, DOE, 1987a), and Site Specific Monitoring Plans/Remedial Investigation Plans (SSMP/RIP) Each monitoring plan typically consists of the following Sampling Plan, Data Management Plan, Health and Safety Plan, and Quality Assurance/Quality Control Plan

Installation and site specific monitoring plans were submitted to EPA and CDH in February 1987 (DOE, 1987a and 1987b) The IGMP is the Rocky Flats Plant Comprehensive Source and Plume Characterization Plan, and the SSMP is the Remedial Investigation (RI) Work Plan for CEARP Phase 2 field activities at the high-priority sites (881 Hillside Area) and other priority sites including the 903 Pad, Mound, and East Trenches Areas Phase I field activities were completed in the 903 Pad, Mound, and East Trenches Areas during 1987, and a draft RI report was submitted to EPA and CDH on December 31, 1987 (Rockwell International, 1987b) This Phase II RI Sampling Plan presents site-specific plans for further field work based on results presented in the draft RI report

1 2 WORK PLAN OVERVIEW

This Phase II Remedial Investigation (RI) Sampling Plan for the 903 Pad, Mound, and East Trenches Areas presents results of the Phase I RI site investigation, defines data quality objectives and data needs based on that investigation, and presents a sampling plan to supply data that meet those objectives Section 1 0 (Introduction) presents site locations and descriptions, and Section 2 0 presents results of the Phase I RI Included in Section 2 0 are Phase I characterization results for site geology and hydrology as well as the nature and extent of contamination in soils, ground water, and surface water Section 3 0 discusses data quality objectives for the Phase II investigation Section 4 0 presents the data requirements and the sampling plan to satisfy these data requirements, and Section 5 0 presents sampling and analysis methods

1 3 DESCRIPTION OF CURRENT SITUATION

This section provides background information on the environmental setting and operation at the Rocky Flats Plant

1 3 1 Site History

The Rocky Flats Plant is a government-owned, contractor-operated facility, which is part of the nationwide nuclear weapons production complex The facility was located at Rocky Flats after the U S Government decided to expand its nuclear weapons capability in 1950 and has been in operation since 1951 The Plant was operated for the U S Atomic Energy Commission (AEC) from its inception until the AEC was dissolved in January 1975 At that time, responsibility for the Plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the Department of Energy (DOE) in 1977 The Plant is operated under the direction of the DOE Albuquerque Operations Office (ALO) Dow Chemical U S A , an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975 Rockwell International was selected to succeed Dow Chemical as the prime contractor responsible for operating the Rocky Flats Plant, beginning July 1, 1975

1 3 1 1 Plant Operations

The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium, uranium and other non-radioactive metals (principally beryllium and stainless steel) Parts made at the Plant are shipped elsewhere for assembly In addition, the Plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium and americium The Plant has specialized facilities and equipment for handling these materials, as well as personnel with extensive knowledge of and experience with the chemistry and fabrication properties of these materials

Both radioactive and nonradioactive wastes are generated in the production process Current waste handling practices involve onsite and offsite recycling of hazardous materials and offsite disposal of solid radioactive materials at another DOE facility However, both storage and disposal of hazardous and radioactive wastes occurred onsite in the past Preliminary assessments under CEARP identified some of the past onsite storage and disposal locations as potential sources of environmental contamination

1 3 1 2 Previous Investigations

Various studies have been conducted at the Rocky Flats facility in order to assess the extent of radiological and chemical contaminant releases to the environment A detailed description of the geology has been presented in previous studies (Malde, 1955, Spencer, 1961, Scott, 1963, 1965, and 1972, Van Horn, 1972, DOE, 1980, Dames and Moore, 1981, and Robson et al, 1981b

A series of investigations has been conducted at the Plant to characterize ground water, surface water, soils, air quality and biota The investigations performed prior to 1986 are summarized in Rockwell International (1986g) and include

1) Several drilling programs beginning in 1961 that resulted in approximately 60 monitor wells by 1985,

2) An investigation of surface and ground water by the U S Geological Survey (Hurr, 1976),

3) Environmental, ecological and public health studies which culminated in an environmental impact statement (DOE, 1980),

4) An integrative report on ground-water hydrology using data from 1961 to 1985 (Hydro-Search, Inc , 1985),

5) A preliminary electromagnetic survey of the Plant perimeter (Hydro-Search, Inc , 1986),

6) A soil gas survey of the Plant perimeter and buffer zone (Tracer Research, Inc , 1986), and

7) Routine environmental monitoring programs addressing air, surface water, ground water and soils (Rockwell International, 1975 through 1985, 1986f, and 1987a)

In 1986, two major investigations were completed at the Plant The first was the CEARP Phase 1 installation assessment (DOE, 1986b) which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported A number of sites were identified that could potentially have adverse impacts on the environment These sites were designated as solid waste management units (SWMUs) and were divided into three categories

1) hazardous waste management units that will continue to operate and need a RCRA operating permit,

2) hazardous waste management units that will be closed under RCRA interim status, and

3) inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA No RCRA or CERCLA regulatory distinction in the use of the terms "site", "unit", or "SWNV" is intended in this document

The second major investigation completed at the Plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire facility Results of the study were reported in Rockwell International (1986a) This investigation resulted in the identification of four areas which are the most probable sources of environmental contamination, with each area containing several sites The areas are the 881 Hillside Area, the 903 Pad Area, the Mound Area and the East Trenches Area Sites at the 881 Hillside area were selected as the high priority sites because of the high concentrations of volatile organic compounds detected in the ground water, the relatively permeable soils and the proximity of the area to a surface water drainage

A remedial investigation of and feasibility study for the high priority sites (881 Hillside Area) has already been completed Phase I of the remedial investigation was completed in July, 1987, and Phase II was completed in March, 1988 (Rockwell International, 1988a) A draft feasibility study was also completed in March, 1988 (Rockwell International, 1988b)

Phase I remedial investigations of the other priority sites (903 Pad, Mound and East Trenches Areas) were completed in December 1987 (Rockwell International, 1987b) Work on the feasibility study is currently in progress and this document is the work plan for Phase II remedial investigations of these sites

1 4 GENERAL SETTING

A brief description and summary of the regional and environmental setting of the Rocky Flats Plant is presented below to provide a basis for understanding potential contaminant pathways

1 4 1 Socioeconomic Setting

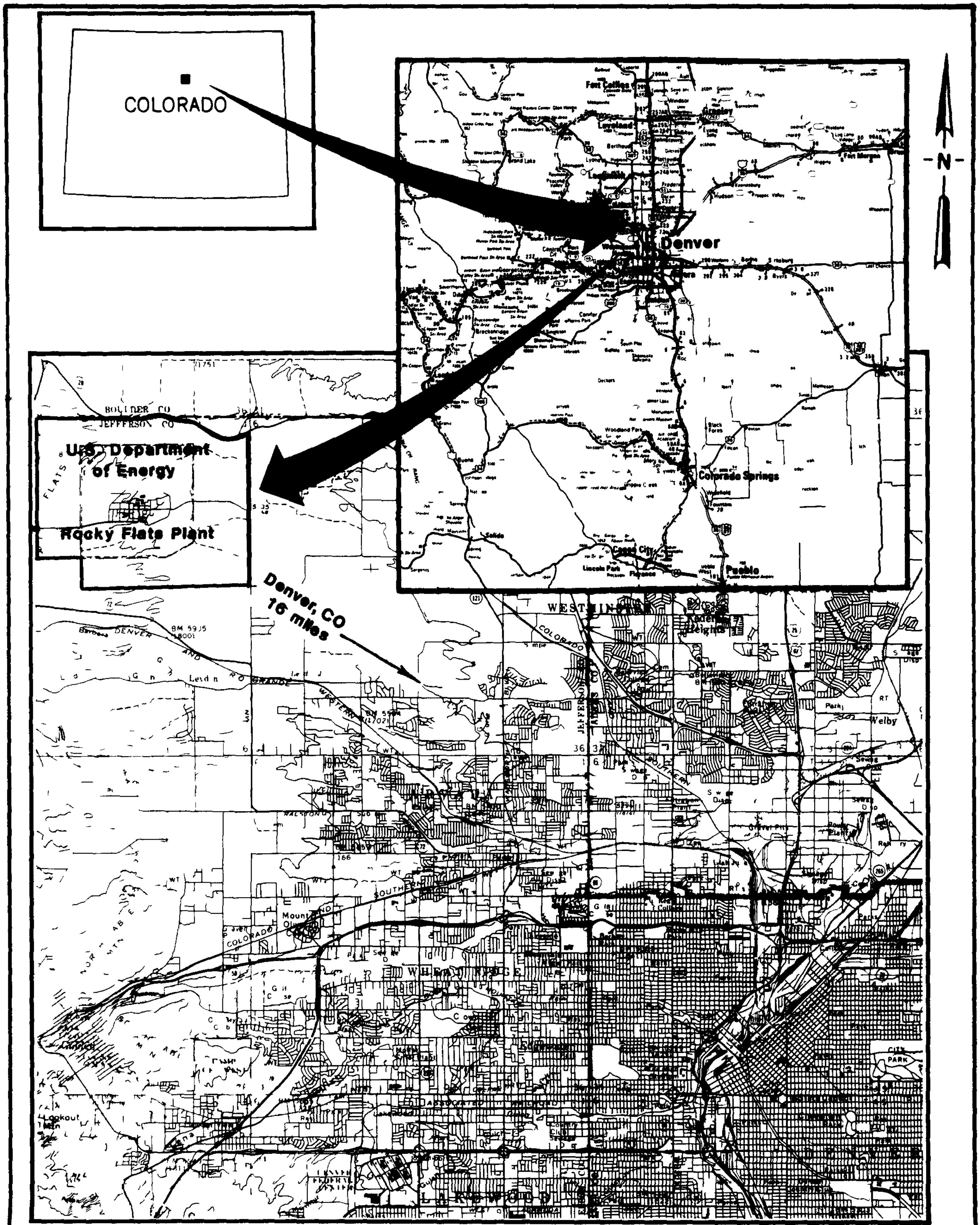
The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1) The Plant consists of approximately 6,550 acres of federally owned land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian Major buildings are located within the Plant security area of approximately 400 acres The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 1-2)

The area in the immediate vicinity of the Plant is primarily agricultural or undeveloped Prior to 1975, the buffer zone was used by its former owners for grazing of cattle and horses No grazing has been allowed since that time No major public facilities or institutions (such as schools, prisons, or hospitals) are located within five miles of the Plant There are four commercial/industrial facilities within five miles of the Plant that employ approximately 300 people Several population centers are located within ten miles, the closest is the small community of Leyden approximately 3 3 miles south of the Plant Broomfield, Arvada, Golden and Boulder are all within nine to twelve miles of the Plant

1 4 2 Environmental Setting

1 4 2 1 Topography

The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains The Plant is directly east of the north-south trending Rocky Mountains, with an elevation of approximately 6,000 feet above sea level Rocky Flats Plant is located on a broad, eastward sloping



Not To Scale

Figure 1-1: Location of Rocky Flats Plant

plain of overlapping alluvial fans developed along the Front Range The fans extend about five miles in an eastward direction from their origin in the abruptly rising Front Range and terminate on the east at a break in slope to low rolling hills The continental divide is about 16 miles west of the Plant The operational area at the Plant is located near the eastern edge of the fans on a terrace between stream-cut valleys (North Walnut Creek and Woman Creek) The Rocky Flats Alluvium (the deposit of coalescing alluvial fans) is exposed at the surface and consists of a topsoil layer underlain by as much as 100 feet of silt, clay, sand and gravel

1 4 2 2 Hydrology

Area hydrology is influenced by the thin permeable topsoil layer of the Rocky Flats Alluvium The result is little water retention in the soil, as evidenced by sparse vegetation in the area Surface water and ground-water flow is from west to east, originating in the Front Range Most ground water eventually surfaces to join the natural streams traversing the site

Three intermittent streams drain the Plant Rock Creek drains the northwest corner, Woman Creek, the southern third, and North and South Walnut Creek, the remainder Interceptor ditches have been constructed to collect and divert all runoff from plant operational areas Retention ponds have been constructed in the drainages adjacent to the Plant so that all water can be monitored before discharge in accordance with Plant National Pollution Discharge Elimination System (NPDES) permit

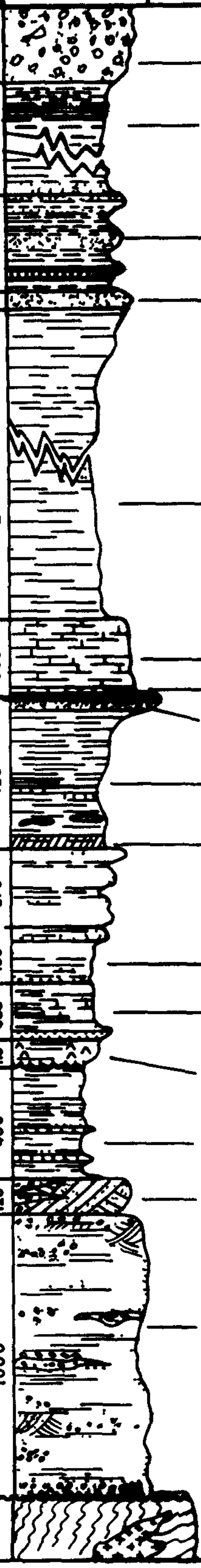
1 4 2 3 Hydrogeology

Geologic units at the Rocky Flats Plant (in descending order) are the surficial units (Rocky Flats Alluvium, Valley Fill Alluvium, and colluvium), the Arapahoe Formation, the Laramie Formation and the Fox Hills Sandstone (Figure 1-3) Ground water occurs in the surficial units and in sandstones in the Arapahoe Formation and the Laramie-Fox Hills aquifer

Rocky Flats Alluvium

The Rocky Flats Alluvium which underlies the plant dominates the hydrology of the area The alluvium is a broad planar deposit consisting of a topsoil layer underlain by zero to 75 feet or more of silt, clay, sand and gravel The Rocky Flats Alluvium is relatively permeable Recharge to the alluvium is from precipitation, snowmelt, and water losses from ditches, streams, and ponds that are cut into the alluvium General water movement in the Rocky Flats Alluvium is from west to east and towards the drainages Discharge from the alluvium occurs at minor seeps and springs in the colluvium that covers the contact of the alluvium and the Arapahoe and Laramie Formations along the edges of the valleys Ground-water flow is controlled by buried channels in the bedrock The water table in the Rocky Flats Alluvium rises in response to recharge during the spring and declines during the remainder of the year

The Rocky Flats Alluvium terminates east of the Plant boundary and, therefore, does not supply water to wells located downgradient of Rocky Flats Plant However, the alluvium discharges to surface water the retention ponds and the underlying bedrock units



AGE	FORMATION	[illegible]	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600'	Boulder conglomerate with occasional thin siltstone lenses
UPPER CRETACEOUS	Denver-Arapahoe	1200'	Tan sandy claystone and clayey sandstone, conglomerate at base, includes Table Mountain "flow" rocks to the north
	Laramie	500'	Gray, fine-to-medium-grained sandstone and silty clays, thin coal beds in lower part
	Fox Hills	50'	Tan, fine-to-medium-grained sandstone and sandy shale
	Pierre	± 8000'	Dark gray, silty shale and few thin, silty sandstones
	Niobrara	350'	Dark gray, very calcareous shale "Foraminifers" abundant (Smoky Hills Member) Light gray, dense, fossiliferous limestone(Fort Hays Member)
	Benton	420'	Brown, sandy, fossiliferous limestone Dark gray shale with bentonite streaks, thin limestones in middle part, few cone-in-cone concretions in lower part Dark gray, brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group: So Platte	270'	Light gray, fine-to-medium-grained sandstone, several dark gray shales in middle part
	Dakota Group: Lytle	100'	Light gray, fine-to-coarse-grained, locally conglomeratic sandstone, frequent red and green siltstone interbeds
Jurassic	Morrison	365'	Gray to greenish-gray to red shale and siltstone, thin limestones in middle part, lenticular sandstones in upper and lower part
	Ralston Creek	110'	Light tan siltstone and light red, silty shale, gypsiferous, sandstone at base and locally conglomeratic
Triassic? / PERMIAN	Lykins	400'	Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120'	Grayish-white, fine-to-medium-grained cross-bedded sandstone, conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000'	Red, fine-to-coarse-grained sandstone and conglomerate, arkosic, thin, lenticular red siltstones frequent throughout
PRECAMBIAN			Gneiss, schist, and small granitic intrusions

Figure 1-3: Generalized Stratigraphic Section, Golden-Morrison Area

(after LeRoy and Weimer, 1971)

Valley Fill Alluvium and Colluvium

Alluvium in the valleys and stream channels is usually coarser and more sorted than the Rocky Flats Alluvium and, therefore, is more permeable The alluvium in the stream channels is approximately 10 feet thick Studies have indicated that ground-water movement in the valley fill alluvium is relatively rapid (Hurr, 1976, Rockwell, 1988a)

Ground water in the colluvium along the bottom of the valleys in the vicinity of the Plant is recharged by precipitation, by percolation from streams during periods of surface water runoff, and by seeps and springs discharging from the Rocky Flats Alluvium Discharge from the valley fill alluvium is by evapotranspiration and by seepage into other geologic formations and streams The direction of ground-water flow generally is along the course of the stream During periods of high surface water flow, water is lost to bank storage in the alluvium and returns to the stream after the runoff subsides

The movement of ground water into and out of the valley fill alluvium varies along the length of the valleys In the upper reaches of the valleys where the valley fill is underlain by the Rocky Flats Alluvium, water moves from the valley fill directly into the Rocky Flats Alluvium Downstream, where the valley bottom is below the base of the Rocky Flats Alluvium, water moves from the Rocky Flats Alluvium into the valley fill Where the valleys have been cut into bedrock, water moves from the streams into the valley fill and then recharges the underlying bedrock formation (DOE, 1986b)

Arapahoe Formation

The Arapahoe Formation underlies the Rocky Flats Alluvium beneath the Plant area The Arapahoe consists of claystone with thin lenses of sandstone It varies in thickness from zero to 270 feet The permeable zones of the Arapahoe are lenticular sandstones within the claystone The lenticular sand bodies are composed of fine-grained sands and silts, and their hydraulic conductivity is low compared to the overlying Rocky Flats Alluvium

The Arapahoe Formation is recharged by leakage from streams and ground-water movement from overlying surficial deposits The main recharge areas are under the Rocky Flats Alluvium, although some recharge from the valley fill alluvium occurs along the stream valleys north and south of the plant (DOE, 1980) Recharge is greatest during the spring and early summer when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium are high

Ground-water movement in the Arapahoe Formation is generally toward the east Although there are a few seeps along the sides of the valleys where the Arapahoe Formation outcrops, most of the ground water flows eastward, out of the area The general direction of movement is toward the South Platte River in the center of the Denver Basin (Robson et al, 1981a)

Laramie-Fox Hills Aquifer

The Laramie Formation underlies the Arapahoe and is composed of two units, a thick upper claystone and a lower sandstone The claystone is greater than 700 feet thick and is of very low hydraulic conductivity, therefore, Hurr (1976) concludes that plant operations will not impact any units below the upper claystone unit of the Laramie Formation

The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Sandstone comprise a regionally important aquifer known as the Laramie-Fox Hills Aquifer The aquifer subcrops west of the plant and can be seen in clay pits excavated through the Rocky Flats Alluvium The steeply dipping beds of the aquifer quickly flatten to the east Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and leakage along the Front Range (Robson et al 1981b)

1 4 2 4 Meteorology

The area surrounding the Rocky Flats Plant has a semiarid climate characteristic of much of the central Rocky Mountain region Approximately forty percent of the 15-inch annual precipitation falls during the spring season, much of it as wet snow Thunderstorms (June to August) account for an additional thirty percent of the annual precipitation Autumn and winter are drier seasons, accounting for nineteen and eleven percent of the annual precipitation, respectively Snowfall averages 85 inches per year, falling from October through May (DOE, 1980)

Special attention has been focused on dispersion meteorology surrounding the Plant due to the remote possibility that significant atmospheric releases might affect the Denver metropolitan area Studies of air flow and dispersion characteristics are available (e g , Hodgin, 1984) The studies indicate that drainage flows (winds coming down off the mountains to the west) turn and move toward the north and northeast along the South Platte River valley and pass to the west and north of Brighton, Colorado These drainage flows are of particular interest because they occur under stable atmospheric dispersion conditions (generally at night) when atmospheric mixing is limited Thus, a release to the atmosphere under worst case dispersion conditions would not be expected to move directly over Denver (DOE, 1986b)

1 4 2 5 Air Pathway

Air pathway studies at the Plant are performed continuously and reported annually in the Annual Environmental Monitoring Reports (e g, Rockwell International, 1975 through 1985, 1986f, and 1987a) In addition, the air pathway was further characterized in Rockwell International (1986e)

Air samplers for routine ambient air monitoring at the plant are located at various locations on and off the Plant site The ambient air program monitors radionuclide concentrations, conventional air quality parameters are monitored on site at a dedicated location inside the perimeter security fence, west of the East Guard Gate

The Plant Radioactive Ambient Air Monitoring Program (RAAMP) consists of 51 high-volume particulate air samplers which operate continuously Twenty-three of the 51 samplers are within or directly adjacent to the Plant security area (on site samplers) and 14 are located around the property boundary (perimeter samplers) An additional 14 samplers are located in neighboring towns (community samplers)

Data collected by the RAAMP indicate a low potential for significant human exposure to radioactive and nonradioactive airborne emissions from the plant All perimeter and community ambient air samplers have recorded mean annual plutonium concentrations of less than 0 4 percent of the Derived Concentration Guide (DCG), which is based on the DOE interim standard dose limit for all pathways of 0 1 rem per year for a 50-year committed effective dose equivalent (Rockwell International, 1986g) This level is indistinguishable from fallout

1 4 2 6 Radiation

The background radioactivity in the vicinity of the Rocky Flats Plant comes from both natural and man-made sources Natural background radiation in the general area is significantly higher than in the United States as a whole (Klement et al, 1972 and CDH, 1976) The higher natural background is due to the elevation of the area and the geologic deposits containing naturally radioactive materials such as uranium and thorium

Man-made releases of long-lived radioisotopes have added to the background radiation These contributions are a small fraction of the natural background radiation level Fallout from past nuclear weapons testing in Nevada and New Mexico has contributed about the same background plutonium levels to the Rocky Flats areas as in the rest of the United States

In addition to the background radiation discussed above, there is radiation from past releases of long-lived alpha activity from the Plant This radiation is greatest near the Rocky Flats Plant and drops off quickly with increasing distance from the Plant The past releases have led to some contamination of the surface water, pond sediments and soil

1 4 2 7 Biota

Plant and animal life is typical of that found in nearby areas Several species of small mammals and larger animals inhabit the site The small intermittent streams flowing through the site do not support large aquatic communities, but a variety of species are present Following consultation with the U S Fish and Wildlife Service, a finding or no effect on threatened or endangered species has been made

1 5 SITE LOCATIONS AND DESCRIPTIONS

The remedial investigation addresses the 903 Pad, Mound, and East Trenches Areas located on the east side of the Rocky Flats Plant security area These areas were selected because of their suspected relationship to ground-water contamination (DOE, 1987b) For convenience, all sites have been assigned a Solid Waste Management Unit (SWMU) reference number The term "site" is used interchangeably with the term "SWMU" throughout this document Several SWMUs are included in each area because of their physical proximity to each other Figure 1-4 shows the locations of each area and presents the SWMU locations within each area Descriptions of the SWMUs are presented in Appendix 1 of the RCRA Part B Operating Permit Application (Rockwell International, 1987c) Each SWMU has been assigned a reference number A base map and a tabulation of all SWMUs cross-referenced to the CEARP Phase 1 report is contained in the IGMP Monitoring Plan for Rocky Flats Plant (DOE, 1987a)

The SWMU descriptions presented in the following sections are taken from the Rocky Flats Plant CEARP Phase 1 Report (DOE, 1986b) and the RCRA Part B

Operating Permit Application (Rockwell International, 1987c) These descriptions are based on historical records, aerial photography review, and interviews with Plant personnel Further characterization of each site based on the Phase I RI is presented in Section 1

1 5 1 903 Pad Area

Five sites are located within the 903 Pad Area These sites are

- 903 Drum Storage Site (SWMU Ref No 112),
- 903 Lip Site (SWMU Ref No 155),
- Trench T-2 (SWMU Ref No 109),
- Reactive Metal Destruction Site (SWMU Ref No 140), and
- Gas Detoxification Site (SWMU Ref No 183)

Presented below are brief descriptions of each of these sites

1 5 1 1 903 Drum Storage Site (SWMU Ref No 112)

The site was used from 1958 to 1967 to store drums containing radioactively contaminated used machine cutting oil The drums contained oils and solvents contaminated with plutonium or uranium Most of the drums contained lathe coolant consisting of mineral oil and carbon tetrachloride (CCl_4) in varying proportions However, an unknown number of drums contained hydraulic oils, vacuum pump oils, trichloroethene (TCE), tetrachloroethene (PCE), silicone oils, and acetone (Rockwell International, 1987c) Ethanolamine was also added to new drums after 1959 to reduce the drum corrosion rate All drums were removed by 1968

After the drums were removed, efforts were undertaken to scrape and move the plutonium-contaminated soil into a relatively small area, cover it with fill material, and top it with an asphalt containment cover This remedial action was completed in November 1969 An estimated 5,000 gallons of liquid leaked into the soil during use of the drum storage site The liquid was estimated to contain 86 grams of plutonium (Rockwell International, 1987c)

1 5 1 2 903 Lip Site (SWMU Ref No 155)

During drum removal and cleanup activities associated with the 903 Drum Storage Site, winds redistributed plutonium beyond the pad to the south and east Although some plutonium-contaminated soils were removed, radioactive contamination is still present at the 903 Lip Site in the surficial soils

1 5 1 3 Trench T-2 (SWMU Ref No 109)

This trench was used prior to 1968 for the disposal of sanitary sewage sludge and flattened drums contaminated with uranium and plutonium

1 5 1 4 Reactive Metal Destruction Site (SWMU Ref No 140)

This site was used during the 1950s and 1960s primarily for the destruction of lithium metal (DOE, 1986b) Small quantities of other reactive metals (sodium, calcium, and magnesium) and some solvents were also destroyed at this location (Rockwell International, 1987c)

1 5 1 5 Gas Detoxification Site (SWMU Ref No 183)

Building 952, located south of the 903 Drum Storage Site, was used to detoxify various gases from lecture bottles between June 1982 and August 1983

1 5 2 Mound Area

The Mound Area is composed of four sites These are

- Mound Site (SWMU Ref No 113),
- Trench T-1 (SWMU Ref No 108),
- Oil Burn Pit No 2 (SWMU Ref No 153), and
- Pallet Burn Site (SWMU Ref No 154)

These sites are described individually below

1 5 2 1 Mound Site (SWMU Ref No 113)

The Mound Site contained approximately 1,405 drums filled with depleted uranium and beryllium wastes The wastes were mostly solid, however, some drums were filled with lathe coolant, and some drums may have contained Perclene, a brand name of PCE (Sax and Lewis, 1987) Cleanup of the Mound Site was accomplished in 1970, and the materials removed were packaged and shipped to an off-site DOE facility as radioactive waste Subsequent surficial soi sampling in the vicinity of the excavated Mound Site indicated 0 8 to 112 5 disintegrations per minute per gram (d/m/g) alpha activity This radioactive contamination is thought to have come from the 903 Drum Storage Site rather than from the Mound Site (Rockwell International, 1987c)

1 5 2 2 Trench T-1 (SWMU Ref No 108)

The trench was used from 1952 until 1962 and contains approximately 125 drums filled with depleted uranium chips coated with lathe coolant The drums are still present in this trench

1 5 2 3 Oil Burn Pit No 2 (SWMU Ref No 153)

Oil Burn Pit No 2 is actually two parallel trenches which were used in 1957 and from 1961 to 1965 to burn 1,083 drums of oil containing uranium (Rockwell International, 1987c) The residues from the burning operations and some flattened drums were covered with backfill The pit was subsequently cleaned up and removed during the 1970s Cleanup operations required the excavation of a hole approximately five feet deep (Rockwell International, 1987c)

1 5 2 4 Pallet Burn Site (SWMU Ref No 154)

An area southwest of Oil Burn Pit No 2 was reportedly used to destroy wooden pallets in 1965 The types of hazardous substances or radionuclides that may have been spilled on these pallets is unknown This site was cleaned up and removed in the 1970s (DOE, 1986b)

1 5 3 East Trenches Area

The East Trenches Area consists of nine burial trenches (Trenches T-3 through T-11) Trenches T-3, T-4, T-10, and T-11 are north of the east access road, and Trenches T-5 through T-9 are south of the east access road The trenches were used from 1954 to 1968 for disposal of depleted uranium, flattened depleted uranium and plutonium-contaminated drums, and sanitary sewage sludge

1 6 PHASE I RI

The Phase I RI consisted of the following field activities

1) Electromagnetic, resistivity, and magnetometer geophysical surveys,

2) A soil gas survey,

3) Soil sample collection from 33 boreholes,

4) Completion of 10 alluvial and 14 bedrock monitoring wells,

5) Well development,

6) Ground-water sampling of new and previously existing wells,

7) Slug testing of 13 wells,

8) Packer testing of cored bedrock wells,

9) Collection of 22 surface water and seep samples, and

10) Air monitoring for total long lived alpha, plutonium, and volatile organics during field activities

In addition to the Phase I investigation at the 903 Pad, Mound, and East Trenches Areas, several monitor wells were installed in these areas as part of a Plant-wide hydrogeologic investigation in 1986 (Rockwell International, 1986a) Surface water, soil, and air samples have also been collected at these areas as part of various investigations Section 2 0 presents results of the Phase I RI and a brief characterization of each pathway at the 903 Pad, Mound, and East Trenches Areas The nature and extent of contamination associated with these pathways is discussed in Section 2 2

1 7 PURPOSE OF PHASE II RI

Based on information obtained during preparation of the Phase I RI report, a second phase of field work and data analysis will be performed Objectives of the Phase II RI include

1) Define the extent (vertical and lateral) of radionuclide contamination in surficial soils at the 903 Pad, Mound and East Trenches Areas,

2) Define the extent of volatile organic soil contamination at selected sites,

3) Define the extent of alluvial ground-water contamination,

4) Define the extent of organic bedrock ground-water contamination, and

5) Fill data gaps in existing hydrogeologic conceptual model

Details of Phase I results and specific objectives of the Phase II investigation are identified in sections 2 0, 3 0, and 4 0

2 0 PHASE I SITE EVALUATION

2 1 SITE CONCEPTUAL MODEL

A site-specific conceptual model of the 903 Pad, Mound, and East Trenches Areas has been developed based on the Phase I RI results and previous investigations This model describes the pathways through which contaminant transport may occur from these areas

2 1 1 Geology

2 1 1 1 Surficial Geology

Surficial materials at the 903 Pad, Mound, and East Trenches Areas consist of the Rocky Flats Alluvium, colluvium, and valley fill alluvium unconformably overlying bedrock (Plate 2-1) All of the study areas are situated on a terrace of Rocky Flats Alluvium which extends eastward from the Plant The Rocky Flats Alluvium consists of a poorly to moderately sorted, poorly stratified, deposit of clays, silts, sands, gravels, and cobbles A portion of the 903 Pad Area extends south off the terrace toward the South Interceptor Ditch Colluvium is present on the hillside south of the 903 Pad and East Trenches Areas and on the hillside north of the Mound Area Valley fill alluvium is present in the drainage of Woman Creek south of the 903 Pad and East Trenches Areas and in the South Walnut Creek drainage north of the Mound Area

Buried valleys and ridges eroded into the top of bedrock are present at the base of the Rocky Flats Alluvium (Plate 2-2) One such paleovalley is located north of the 903 Pad Area along Central Avenue The paleovalley is approximately 300 feet wide and 2,000 feet long It trends east-northeast beneath the east access road and bends to the southeast just south of well 33-87 Near well 32-87, the paleovalley is joined by another paleovalley which is at least 3,000 feet long, 400 feet wide and trends northeast toward well 39-86 A 150 feet wide paleoridge located east of well 15-87 separates the two paleovalleys Another paleoridge occurs beneath the northern edge of the Rocky Flats Alluvium terrace east of the Mound Area and north of the East Trenches (well 35-87)

2 1 1 2 Bedrock Geology

The Cretaceous Arapahoe Formation underlies surficial materials at the 903 Pad, Mound, and East Trenches Areas Sixteen wells were completed in various zones within the bedrock during the 1987 drilling program (see Plate 2-4) The Arapahoe Formation consists of fluvial claystones with interbedded lenticular sandstones, siltstones, and occasional lignite deposits Contacts between these lithologies are both gradational and sharp

Claystone was the most frequently encountered lithology of the Arapahoe Formation immediately below the alluvium/bedrock contact Weathered bedrock was encountered directly beneath surficial materials in all of the boreholes and wells

Saturated sandstones were found in wells 9-87BR, 12-87BR, 23-87BR, and 25-87BR directly below surficial materials (subcropping), and in wells 62-86, 11-87BR, 14-87BR, and 36-87BR near the alluvium/bedrock contact Bedrock wells 40-86, 16-87BR, 18-87BR, 20-87BR, 22-87BR, 28-87BR, 30-87BR, and 31-87BR are completed in deeper saturated sandstones The Arapahoe sandstones are generally lenticular and somewhat discontinuous, however, some of the sandstone units have been correlated for lateral distances as great as 500 feet (Plates 2-5 through 2-8)

The sandstone correlations are based on similar lithologies in relatively closely spaced wells They are also based on the consistency of the resulting dip with dips found at nearby areas that have also been studied in detail The key sandstone correlation is the correlation of the similar sandstone lithologies in wells 9-87BR and 16-87BR (Sandstone Z shown on Cross Section A-A', Plate 2-5) The sandstones in these wells are believed to be the same sandstone because both are coarser (medium- to fine-grained) and contain less silt than the other sandstones encountered in the investigation The base of the sandstone correlated between 9-87BR and 16-87BR is dipping approximately 7 degrees to the east (using the approximately north-south strike of the Fox Hills Sandstone west of the plant) This dip is consistent with the calculated sandstone dips in the 881 Hillside Area (Rockwell International, 1988a) Therefore, sandstones were projected on the cross sections using a 7 degree dip and found to correlate with sandstones in other wells (Plate 2-5 through 2-8)

2 1 2 Hydrogeology

Ground water occurs in surficial materials (Rocky Flats Alluvium, colluvium, and valley fill alluvium) and in Arapahoe sandstones at the 903 Pad, Mound, and East Trenches Areas These two hydraulically connected flow systems are discussed separately below

2 1 2 1 Unconfined Flow System in Surficial Materials

Recharge/Discharge Conditions

Ground water is present in the Rocky Flats Alluvium, colluvium, and valley fill alluvium under unconfined conditions Recharge to the water table occurs as infiltration of incident precipitation and as seepage from ditches and creeks In addition, retention ponds along South Walnut Creek and Woman Creek probably recharge the valley fill alluvium

The shallow ground-water flow system is quite dynamic, with large water level changes occurring in response to precipitation events and stream and ditch flow For example, between mid-April and September, 1986, water levels in wells 1-86 and 4-86 (completed in valley fill alluvium) dropped more than four and eight feet, respectively Alluvial water levels are highest during the spring and early summer months of May and June Water levels decline during late summer and fall, and some wells go completely dry at this time of year

Alluvial ground water discharges to seeps, springs, surface water drainages, and subcropping Arapahoe sandstone at the 903 Pad, Mound, and East Trenches Areas Seeps and springs occur along the edge of the Rocky Flats Alluvium terrace (at the alluvium/bedrock contact) and on the side slopes of the terrace Seeps and springs on the terrace side slopes may be due to thinning of colluvial materials Ground water in colluvial materials south of the 903 Pad and East Trenches Areas discharges to the South Interceptor Ditch, and ground water in valley fill materials discharges to Woman or South Walnut Creeks

Ground-water Flow Directions

Ground-water flow in the Rocky Flats Alluvium is generally from west to east following the buried topography on top of claystone bedrock Plate 2-9 presents the potentiometric surface in surficial materials measured on December 1, 1987 Because of the bedrock highs beneath the Rocky Flats Alluvium in the East Trenches Area, ground-water flow is diverted either toward the paleovalleys or off the edge of the Rocky Flats terrace Water diverted toward the paleovalleys flows northeast following the trend of the valleys Ground water flowing toward the terrace edges emerges as seeps and springs at the contact between the alluvium and claystone bedrock (contact seeps), is consumed by evapotranspiration, or flows through colluvial materials following topography toward the valley fill alluvium Once ground water reaches the valley fill alluvium, it either flows down-valley in the alluvium, is consumed by evapotranspiration, or discharges to the creek During the driest periods of the year, evapotranspiration consumes so much water that there is no flow in either the colluvium or the valley fill alluvium

The saturated thickness in surficial materials varied from 0 (well 63-86) to 9 feet (well 17-87) on December 1, 1987 Plate 2-9 shows an area of little to no saturation in the Rocky Flats Alluvium and colluvium west and south of the 903 Pad Area The absence of alluvial ground water in these areas is due to either

1) discharge of ground water to the surface system (seeps and springs) where bedrock is at or near the ground surface,

2) discharge of ground water to the atmosphere as evaporation from the capillary fringe and as transpiration from phyreatophytes, or

3) recharge to subcropping bedrock sandstones from alluvial ground water

Wells completed in these areas have been dry, moisture content observations from boreholes also indicate unsaturated conditions

Ground-water Flow Rates

Hydraulic conductivity values were developed for surficial materials from drawdown-recovery tests performed on 1986 wells during the initial site characterization (Rockwell International, 1986a) and from slug tests performed on select 1986 and 1987 wells during the 1987 Phase I RI

For the Rocky Flats Alluvium, the geometric mean hydraulic conductivity for all tests is 4 x 10^{-4} centimeters per second (cm/s) or 418 feet per year (ft/year) Based on an average horizontal gradient of 0 02 feet/foot (ft/ft), an assumed effective porosity of 0 1 and a mean hydraulic conductivity of 418 ft/year, the average ground-water velocity in the Rocky Flats Alluvium is 84 ft/year (Rockwell International, 1987b)

The geometric mean hydraulic conductivity based on drawdown-recovery tests for the Woman Creek valley fill alluvium is 7 x 10^{-4} cm/s (724 ft/year) No slug tests were performed on wells completed in Woman Creek valley fill Using the same gradient and effective porosity as for the Rocky Flats Alluvium and a mean hydraulic conductivity of 724 ft/year, the average ground-water velocity in Woman Creek valley fill is 145 ft/year (Rockwell International, 1987b)

South Walnut Creek valley fill is less conductive than that along Woman Creek based on lithologic descriptions and hydraulic conductivity tests Using the mean conductivity of 9 5 x 10^{-5} cm/s (98 ft/year), an effective porosity of 0 1 and an average gradient of 0 02 ft/ft, the average flow velocity in South Walnut Creek valley fill is 20 ft/year (Rockwell International, 1987b)

The average ground-water flow velocities calculated for various surficial materials assume the materials are fully saturated yea.-round However, as discussed above, portions of the Rocky Flats Alluvium, colluvium, and valley fill alluviums are not saturated during the entire year Thus, dissolved constituents in the shallow flow system do not actually move at the calculated velocities for the entire year

2 1 2 2 Bedrock Ground-water Flow System

Recharge Conditions

The majority of ground-water flow in the Arapahoe Formation occurs in the lenticular sandstones contained within the claystones Ground-water recharge to sandstones occurs as infiltration from alluvial ground water where sandstones subcrop beneath the alluvium and by leakage from claystones overlying the sandstones

There is a strong downward gradient between ground water in surficial materials and bedrock Vertical gradients range from 0 31 ft/ft between wells 35-86 and 34-86 to 1 05 ft/ft between wells 41-86 and 40-86 These gradients imply a relatively high hydraulic conductivity contrast between the sandstones and claystones that is supported by hydraulic conductivity test results

Ground-water Flow Directions

Flow within individual sandstones is from wes to east based on the sandstone correlations between wells 9-87BR and 16-87BR (Plate 2-5) Ground water in well 9-

87BR is unconfined, but confined conditions exist in well 16-87BR The horizontal gradient between these wells is 0 09 ft/ft

Ground-water Flow Rates

Hydraulic conductivity values for Arapahoe sandstones were estimated from drawdown-recovery tests performed in 1986, slug tests performed in 1987, and packer tests performed in 1986 and 1987 Hydraulic conductivity values from drawdown-recovery and slug tests are in good agreement, however, packer test results are approximately two orders of magnitude less than results from the other two test methods The geometric mean hydraulic conductivity from drawdown-recovery tests, slug tests, and packer tests are 4×10^{-5} cm/s (41 ft/yr), 8×10^{-5} cm/s (83 ft/yr), and 4×10^{-7} cm/s (0 4 ft/yr), respectively The drawdown-recovery and slug tests are considered more representative of in-situ conditions because they were performed after development of the wells

The maximum horizontal ground-water flow velocity in sandstone would be 75 ft/yr using a hydraulic conductivity of 83 ft/yr, an average horizontal gradient of 0 09 ft/ft, and an assumed effective porosity of 0 1

The geometry of the ground-water flow path in the bedrock is not fully understood at this time because it depends upon the continuity of the sandstones and their interconnection Evaluation of the lateral extent and degree of interconnection of the sandstone units is a primary goal of the Phase II hydrogeologic characterization at the 903 Pad, Mound, and East Trenches Areas

2 1 3 Surface Water Hydrology

2 1 3 1 South Walnut Creek

The headwaters of South Walnut Creek have been filled during construction of plant facilities, and the most upstream flow begins as flow from a buried culvert located west of Building 991 During Phase I RI surface water sampling (Rockwell International, 1987b), flow in the upper reach of South Walnut Creek was visually estimated at approximately 5 gallons per minute (gpm) This flow is routed beneath Building 991 in a corrugated metal pipe The discharge from the corrugated metal pipe is augmented by flow from a concrete pipe at a point due north of the Mound Area The flow from the concrete pipe (visually estimated at approximately one gpm) apparently originates as seepage from the hillside south of Building 991 and flows into a ditch along the slope The combined flows then enter the South Walnut Creek retention pond system Below the retention ponds, South Walnut Creek joins North Walnut Creek and an unnamed tributary within the buffer zone before flowing into Great Western Reservoir located approximately one mile east of this confluence

The South Walnut Creek retention pond system consists of five ponds (B-1, B-2, B-3, B-4, and B-5) that retain surface water runoff and Plant discharges for monitoring and evaluation before downstream release of these waters All flow downstream of the most downstream pond (Pond B-5) originates from Pond B-5 and is measured and monitored for quality in accordance with the Plant's National Pollutant Discharge Elimination System (NPDES) permit (discharge point 006) Ponds B-1 and B-2 are reserved for spill control, surface water runoff, or treated sanitary waste of questionable quality, and Pond B-3 is a holding pond for sanitary sewage treatment plant effluent The normal discharge of Pond B-3 is to a spray system located in the vicinity of the East Trenches Ponds B-4 and B-5 receive surface water runoff from the central portion of the Plant and occasional discharges from Pond B-3 The surface water runoff received by Pond B-4 is collected by the Central Avenue Ditch and upper reaches of South Walnut Creek

2 1 3 2 Woman Creek

Woman Creek is located south of the Plant with headwaters in largely undisturbed Rocky Flats Alluvium Runoff from the southern part of the Plant is collected in the South Interceptor Ditch located due north of the creek and delivered to the downstream of the two C series ponds, C-2 Pond C-1 (upstream of C-2) receives stream flow from Woman Creek The discharge from Pond C-1 is diverted around Pond C-2 into the Woman Creek channel downstream Water in Pond C-2 is discharged to Woman Creek in accordance with the Plant NPDES permit (discharge point 007)

Flow in Woman Creek and the South Interceptor Ditch is intermittent, appearing and disappearing along various reaches During the 1986 initial site characterization, measurable flow occurred at less than one-half of the ten stations located along Woman Creek and the South Interceptor Ditch (Rockwell International, 1986a) All recorded flows were less than 10 gpm During the 1986 and 1987 investigations, there was no surface flow in Woman Creek downstream of Pond C-2 The intermittent surface water flow observed for Woman Creek and the South Interceptor Ditch is indicative of frequent interaction with the shallow ground-water system

2 2 NATURE AND EXTENT OF CONTAMINATION

2 2 1 Soils

The extent of soil contamination at the 903 Pad, Mound, and East Trenches Areas is based on soil samples collected during Phase I RI field activities Soil samples were taken from boreholes drilled into and adjacent to known SWMU locations and analyzed for the parameters listed in Table 2-1 Boreholes were drilled into SWMUs to the extent practical, however, boreholes were not drilled into SWMUs still containing wastes (the trenches and 903 Pad) due to potential health hazards to field workers and potential for release of waste constituents to the environment Plate 2-4 shows SWMU and borehole locations

2 2 1 1 903 Pad Area

903 Drum Storage and 903 Pad Lip Sites (SWMU Ref Nos. 112 and 155)

Based on results of the soil boring program (Rockwell International, 1987b), it appears soils surrounding the 903 Drum Storage and 903 Pad Lip Sites are contaminated with plutonium, americium, and phthalates Radionuclide contamination (plutonium and americium) appears to be limited to surficial soils, as these contaminants were only found in the uppermost samples, however, this conclusion will be confirmed during Phase II RI field activities (Section 4 2 1 1)

TABLE 2-1

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

Metals

Hazardous Substance List - Metals
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Tin
- Vanadium
- Zinc

Chromium (hexavalent)
Chromium (trivalent)
Lithium
Strontium

TABLE 2-1 (CONTINUED)

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

Organics

Hazardous Substances List -- Volatiles

- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

TABLE 2-1 (CONTINUED)

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

Hazardous Substances List -- Semi-volatiles

- N-Nitrosodimethylamine
- Phenol
- Aniline
- bis(2-Chloroethyl)ether
- 2-Chlorophenol
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- Benzyl Alcohol
- 1,2-Dichlorobenzene
- 2-Methylphenol
- bis(2-Chloroisopropyl)ether
- 4-Methylphenol
- N-Nitroso-Dipropylamine
- Hexachloroethane
- Nitrobenzene
- Isophorone
- 2-Nitrophenol
- 2,4-Dimethylphenol
- Benzoic Acid
- bis(2-Chloroethoxy)methane
- 2,4-Dichlorophenol
- 1,2,4-Trichlorobenzene
- Naphtalene
- 4-Chloroaniline
- Hexachlorobutadiene
- 4-Chloro-3-methylphenol(para-chloro-meta-cresol)
- 2-Methylnaphthalene
- Hexachlorocyclopentadiene
- 2,4,6-Trichlorophenol
- 2,4,5-Trichlorophenol
- 2-Chloronaphthalene
- 2-Nitroaniline
- Dimethyl Phthalate
- Acenaphthylene
- 3-Nitroaniline
- Acenaphthene
- 2,4-Dinitrophenol
- 4-Nitrophenol
- Dibenzofuran
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Diethylphthalate
- 4-Chlorophenyl Phenyl ether
- Fluorene
- 4-Nitroaniline
- 4,6-Dinitro-2-methylphenol

TABLE 2-1 (CONTINUED)

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

Hazardous Substances List -- Semi-volatiles (continued)
- N-nitrosodiphenylamine
- 4-Bromophenyl Phenyl ether
- Hexachlorobenzene
- Pentachlorophenol
- Phenanthrene
- Anthracene
- Di-n-butylphthalate
- Fluoranthene
- Benzidine
- Pyrene
- Butyl Benzyl Phthalate
- 3,3'-Dichlorobenzidine
- Benzo(a)anthracene
- bis(2-ethylhexyl)phthalate
- Chrysene
- Di-n-octyl Phthalate
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

Hazardous Substances List -- Pesticides
- alpha-BHC
- beta-BHC
- delta-BHC
- gamma-BHC (Lindane)
- Heptachlor
- Aldrin
- Heptachlor Epoxide
- Endosulfan I
- Dieldrin
- 4,4'-DDE
- Endrin
- Endosulfan II
- 4,4'-DDD
- Endrin Aldehyde
- Endosulfan Sulfate
- 4,4'-DDT
- Endrin Ketone
- Methoxychlor
- Chlordane
- Toxaphene
- AROCLOR-1016

TABLE 2-1 (CONTINUED)

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

Hazardous Substances List -- Pesticides (continued)
- AROCLOR-1221
- AROCLOR-1232
- AROCLOR-1242
- AROCLOR-1248
- AROCLOR-1254
- AROCLOR-1260

Oil and Grease

<u>Radionuclides</u>

Gross Alpha
Gross Beta
Uranium 233+234, 235 and 238
Americium 241
Plutonium 239+240
Tritium

<u>Other</u>

pH

Hazardous Substances List (HSL) volatile organics were below detection limits in boreholes surrounding these sites However, volatile organics are present in ground water at these sites and are expected to be present in soils beneath the 903 pad Based on soil boring results, the extent of volatile organic soil contamination at the 903 Drum Storage Site is confined to the area immediately beneath and adjacent to the pad Additional boreholes will be drilled immediately adjacent to the pad during the Phase II RI to validate this conclusion In addition, an oil seep recently observed at the site will be investigated with a borehole (not shown on Plate 2-4)

Trench T-2 (SWMU Ref. No. 109)

Based on the Phase I RI results, soils in the vicinity of Trench T-2 are contaminated with plutonium, americium, trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), tetrachloroethene (PCE), and possibly acetone and phthalates Plutonium and americium contamination is particularly high in composite soil samples that include the ground surface, and volatile organic contamination is highest south of the trench in BH25-87 Plutonium was detected in the zero to nine foot composite sample at 3 2 (0 4) picoCuries per gram (pCi/g), and americium was detected at 0 22(0 18) pCi/g The maximum concentrations of volatile organics detected in borehole BH25-87 were 16,000 micrograms per kilogram (ug/kg) of TCE, 10,000 ug/kg of PCE, 250 ug/kg of 1,1,1-TCA, and 1,100 ug/kg of acetone (also detected in the blank) It is postulated that radionuclide contamination originated from the 903 Drum Storage Site via wind dissemination, and the solvent contamination is due to a release from Trench T-2 Additional surficial soil sampling is necessary in the area to ascertain the depth of radionuclide contamination and additional boreholes around the trench are needed to define the extent of solvent contamination

Reactive Metal Destruction Site (SWMU Ref. No. 140)

Solvent contamination in soils at the Reactive Metal Destruction Site was found in the vicinity of BH28-87 based on soil sampling results PCE at 210 ug/kg, carbon tetrachloride (CCl_4) at 100 ug/kg, and carbon disulfide at 58 ug/kg were all above detection limits below the water table in BH28-87 However, as discussed in Section 4 1, these values are below health and technology-based criteria Therefore, further characterization volatile organic compounds (VOC) in soil at the Reactive Metal Destruction Site is not warranted

Plutonium was elevated above background levels in the surface and nine-foot bedrock samples from BH28-87 Surficial radionuclide contamination in this area is attributed to wind dispersal of plutonium from the 903 Drum Storage Site

2 2 1 2 Mound Area

Mound Site (SWMU Ref. No. 113)

No volatile organic contamination was found in soil samples from the Mound Site during the Phase I investigation Additional soil sampling of the surface materials will be performed in the area to identify possible impacts of radionuclide contamination resuspended from the 903 Drum Storage Site Also, the Mound Site location was revised westward during preparation of the Phase I RI report based on review of historical air photos Additional boreholes are needed in the revised SWMU location

Oil Burn Pit No. 2 and Trench T-1 (SWMU Ref. Nos. 153 and 108)

Analytical results indicated the presence of a few HSL organics in soil samples (acetone, methylene chloride, and 1,2-dichloroethane (1,2-DCA) among the volatiles and N-nitrosodiphenylamine, di-n-butyl phthalate, and bis(2-ethylhexyl)phthalate among the semi-volatiles) The detected volatiles are all estimated at concentrations below the detection limit or were present in the applicable laboratory blank at concentrations within a factor of 2 of the concentration in the sample (not reportable following CLP protocol) Of the semi-volatiles listed above, only bis(2-ethylhexyl)phthalate was found at non-estimated concentrations and even the bis(2-ethylhexyl)phthalate concentrations are only slightly above the detection limits Therefore, it is concluded that there is not significant organic contamination of soils in the vicinity of SWMUs 108 and 153

Plutonium and americium were elevated in composited surface soil samples adjacent to Trench T-1 (boreholes BH35-87 and BH36-87) Plutonium was detected at 1 5(0 2) pCi/g and americium was detected at 0 30(0 13) pCi/g in the 0 to 12 foot composite sample from Borehole BH35-87 Plutonium was also detected at 0 53(0 16) pCi/l in borehole BH36-87 (0 to five foot composite sample) Since radionuclide contamination is limited to soil samples which include the ground surface, wind dispersal of plutonium from the 903 Drum Storage Site is the likely source of this contaminant Surficial soils will be sampled at these sites to confirm this hypothesis

Pallet Burn Site (SWMU Ref. No. 154)

Analytical results of soil samples from boreholes BH31-87 and BH32-87 indicate the presence of low concentrations of HSL organics Maximum VOC levels in borehole BH31-87 were 32 ug/kg of 1,2-DCA, 110 ug/kg of acetone, and 20 ug/kg of PCE, and maximum VOC concentrations in borehole BH32-87 were 29 ug/kg of 1,2-DCA and 170 ug/kg of acetone These organic concentrations are below health and technology-based criteria (Section 4 1), and further soil sampling to define the extent of the low levels of VOCs in the vicinity of the borings is not warranted On the other hand, soil sampling is needed to evaluate the depth and extent of the plutonium in soils Furthermore, review of aerial photographs and historical documents during the Phase I RI resulted in revision of the Pallet Burn Site location (Rockwell International, 1987b) Additional soil samples will be collected from borings at the revised location during Phase II activities for analysis of metallic, radiometric, and organic constituents

2 2 1 3 East Trenches Area

Trenches T-3, T-4, T-10, and T-11 (SWMU Ref. Nos. 110, 111.1, 111.7, and 111.8)

Plutonium was elevated in the surface sample from BH39-87 0 82(0 12) pCi/g Additional surficial soil sampling is necessary around this group of trenches to characterize surficial radionuclide contamination

HSL organics were either not present above detection limits or present as suspected laboratory contaminants in boreholes BH39-87 or BH40-87 However, volatile organics are present in well 3-74 north of Trench T-3, and 1,1,1-TCA was above detection limits in BH43-87 (maximum concentration of 130 ug/kg), BH45-87 (maximum concentration of 180 ug/kg), and BH46-87 (maximum concentration of 190 ug/kg) These VOC concentrations are all below health and technology-based criteria presented in Section 4 1 Therefore, additional soil sampling for VOCs is not needed at these sites

Trenches T-5 through T-9 (SWMU Ref. Nos. 111.2 through 111.6)

Based on analytical results of soil samples, 1,2-DCA, acetone, and plutonium are present in soils around the southern trenches The 1,2-DCA contamination appears to be limited to bedrock samples, and acetone concentrations are also at depth Again, additional soil sampling for VOCs at these sites is not needed because contaminant levels are below health and technology-based criteria (Section 4 1) Plutonium contamination is limited to the uppermost soil samples Additional sampling for plutonium profiling will be performed to confirm that plutonium occurs only at the surface

2 2 2 Ground Water

Presented below is a discussion of ground-water quality at the 903 Pad, Mound, and East Trenches Areas The discussion is a review of the Phase I RI results and is based on five quarters of data for 1986 wells (initial 1986 sampling plus four quarters in 1987) and one sampling event for 1987 wells (initial sampling) Samples were analyzed for the parameters listed in Table 2-2

TABLE 2-2

GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

FIELD PARAMETERS
pH
Specific Conductance
Temperature
Dissolved Oxygen*

INDICATORS
Total Dissolved Solids
Total Suspended Solids*

METALS**
Hazardous Substances List - Metals
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Tin
- Vanadium
- Zinc

Chromium (hexavalent)
Lithium
Strontium

ANIONS
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate

TABLE 2-2 (CONTINUED)
GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

ORGANICS

Hazardous Substances List - Volatiles***

- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

Oil and Grease

RADIONUCLIDES

Gross Alpha
Gross Beta
Uranium 233+234, 235, and 238
Americium 241
Plutonium 239+240
Strontium 90
Cesium 137
Tritium

TABLE 2-2 (CONTINUED)

GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

* For surface water samples only
** Dissolved metals for ground-water samples, total and dissolved metals for surface water samples
*** Ground-water samples from the first quarter of 1987, and all surface water samples were analyzed for 9 of the HSL volatiles These volatiles are the chlorinated solvents historically detected in the ground water and are as follows PCE, TCE, 1,1-DCE, 1,2-DCA, t-1,2-DCE, 1,1,1-TCA, 1,1,2-TCA, CCl_4 and $CHCl_3$

2 2 2 1 Background Ground-Water Quality

Data from alluvial and bedrock monitor wells located west of the Plant were evaluated to estimate background ground-water quality for radionuclides, metals, and inorganics Wells located potentially downgradient of the West Spray Field (SWMU 168) were used in the Phase I RI to expand the background data base, which may bias interpretation of background ground-water quality New alluvial and bedrock background wells will be installed at Rocky Flats Plant as part of a background characterization program

2 2 2 2 903 Pad, Mound, and East Trenches Ground-Water Chemistry

Volatile organic compound contamination and possibly strontium and major ion contamination of ground water exists from multiple sources at the 903 Pad, Mound, and East Trenches Areas There may also be some trace metal and radionuclide contamination of ground water at a few locations The elevated major ion and strontium concentrations observed in some instances may represent contamination but in others may only reflect natural geochemical variations in ground water

Additional characterization of background alluvial and bedrock ground-water quality is being performed at Rocky Flats Plant to better evaluate inorganic, trace metal, and radionuclide contamination The discussion presented below primarily concentrates on VOC contamination at the 903 Pad, Mound, and East Trenches Areas

903 Pad Alluvial Ground-Water Chemistry

Organic contamination of alluvial ground water occurs east of the 903 Drum Storage Site at well 15-87 and south of the site at wells 1-71, 2-71, and 29-87 Organic contamination was not observed farther south at wells 64-86 or 65-86 located in the Woman Creek valley fill alluvium or at well 63-86 Well 64-86 has always been dry

The highest concentrations of 1,1-dichloroethene (DCE) [673 micrograms per liter (ug/l)], 1,2-DCA (400 ug/l), trans-1,2 dichloroethene (t-1,2-DCE) (364 ug/l), and TCE (26,000 ug/l) were reported in well 2-71, located in the 903 Pad Area Also in the 903 Pad Area, the highest concentrations of chloroform ($CHCl_3$) (1,525 ug/l at well 1-71), and 1,1,1-TCA (2,892 ug/l at well 1-71) were reported for alluvial ground water The high TCE concentrations in well 2-71 indicate a release from Trench T-2, where soils contained significant concentrations of TCE Because the 903 Drum Storage Site is upgradient of wells 15-87, 1-71, and 2-71, and lathe coolant cut with various solvents was stored at the site, it is postulated that CCl_4 and other volatiles are released by the 903 Drum Storage Site These contaminants also migrate toward well 1-71, but the occurrence of several other volatiles in the soils and ground water at this location suggest a release is also occurring from the Reactive Metal Destruction Site

Farther to the south, ground water at 64-86 and 65-86 had high concentrations of sodium and sulfate similar to that observed near the 903 Pad Area High sodium and sulfate values are also characteristic of the alluvial ground water downgradient of the 881 Hillside Area (Rockwell International, 1988a) Upgradient of the 881 Hillside Area in well 68-86, these major ion concentrations are lower than those in wells 69-86 and 2-71 This suggests either the 881 Hillside Area, the 903 Pad Area, or both contribute the sodium and sulfate in wells 64-86 and 65-86 Regardless, it is clear that VOCs have not migrated to these wells from any source

903 Pad Bedrock Ground-water Chemistry

VOCs were detected in bedrock ground water at 12-87BR, 11-87BR, and 14-87BR The highest contamination was observed at 12-87BR where TCE and PCE were 3570 and 43 ug/l, respectively Well 12-87BR is completed in a subcropping sandstone, and the high TCE value indicates the sandstone is recharged by alluvial ground water similar to that in 2-71 At 11-87BR, TCE and CCl_4 are among the volatile organics present In addition, it appears to be receiving water from the 903 Drum Storage Site based on the presence of CCl_4 Based on the presence of CCl_4 in well 14-87BR and the orientation of the sandstone unit, it appears that this sandstone subcrops in the 903 Pad Area

Mound Alluvial Ground-water Chemistry

The most notable characteristic of alluvial ground water at the Mound Area is the high VOC contamination in well 1-74, which is completed in the Mound Site At well 43-86 to the west, CCl_4 and TCE were present at low concentrations of 6 and 8 ug/l, respectively Closer to 1-74 at well 17-87, all the VOCs were detected except 1,1,1-TCA, 1,1-DCA, and 1,1-DCE The maximum VOC concentration was PCE at 150 ug/l However, at 1-74 all the VOCs except 1,1,1-TCA were detected, and the highest PCE and TCE concentrations in ground water anywhere on Plant site have been reported at this location Data from 1985 through the third quarter of 1987 show that TCE ranges from 6B to 18,000 ug/l (B indicating the compound was also found in the blank) and PCE ranges from 50 to over 100,000 ug/l, therefore, it is concluded that the alluvial ground water near well 1-74 is significantly contaminated with TCE and PCE The other detected VOCs were at lower concentrations, the maximum concentration being 90 ug/l 1,1-DCE

The similarity of ground-water major ion chemistry at the 903 Pad and Mound Areas is consistent with the hydrogeologic data showing alluvial ground water flowing from west to east across both areas The source of the low level organic contamination at 43-86 may be the 903 Drum Storage Site The source of the low level organic contamination at 17-87 may be Trench T-1 (SWMU 108) which is located adjacent to the well, or the 903 Drum Storage Site

Mound Bedrock Ground-water Quality

Wells 18-87BR, 20-87BR and 23-87BR are the bedrock wells in the Mound Area VOCs were not detected in either 20-87BR or 23-87BR, data are not available for 18-87BR It is tentatively concluded that bedrock ground-water contamination does not exist in the Mound Area

East Trenches Alluvial Ground-water Chemistry

Alluvial ground water at the East Trenches Area contains moderately high concentrations of VOCs at the west end of the area These concentrations decrease to the east, and there is no VOC contamination as far downgradient as wells 39-86 and 67-86 The same VOCs (CCl_4, TCE, and PCE) were detected in wells 3-74 and 42-86, however, VOC concentrations were higher at 42-86 Maximum CCL_4, TCE and PCE concentrations ever detected at well 3-74 are 1,200, 400, and 1,080 ug/l, respectively, while maximum CCl_4, TCE, and PCE concentrations ever detected at well 42-86 are 4,835, 1,400, and 3,200 ug/l, respectively The higher VOC concentrations in well 42-86 relative to those in 3-74 may be due to the location of 42-86 in the paleochannel downgradient of the 903 Pad, Mound, and the northern East Trenches Areas Well 3-74 is downgradient of the northern East Trenches Area but is likely not impacted by the 903 Pad and Mound Areas because of the ground-water divide south of this well (Plate 2-9)

East Trenches Bedrock Ground-Water Quality

Volatile organics were present in ground-water samples from bedrock wells at the East Trenches Area Ground-water chemistry indicates that the sandstone in which 25-87BR is completed is recharged by alluvial ground water from the 903 Pad and Mound Areas Additional sampling and analysis is necessary to further define the nature and extent of volatile organic contamination in bedrock ground water at the East Trenches Area

2 2 2 3 Extent of Ground-Water Contamination

Based on initial sampling results, PCE, CCl_4, and TCE are the primary VOC contaminants found in the unconfined ground-water flow system However, it appears volatilization, adsorption, or dilution have reduced VOC concentrations to non-detectable levels as alluvial ground water migrates to the east and toward the drainages VOCs have not been detected at well 39-86 (South Walnut Creek drainage) or at wells 64-86, 65-86, 66-86, or 67-86 (Woman Creek drainage) However, VOC contamination is present in well 41-86 (just east of the East Trenches) and well 29-87 (southeast of the 903 Pad Area) These data indicate that releases from the 903 Pad, Mound, and East Trenches Areas are not leaving the property, however, the extent of the plume in the Rocky Flats Alluvium is not well defined

PCE is the most extensive VOC in ground water at the 903 Pad, Mound, and East Trenches Areas As shown on Plate 2-3, PCE is more extensive in alluvial ground water than is reflected by the soil gas survey Up to 160 ug/l of PCE were detected in well 41-86, while the soil gas survey did not detect any PCE at this location

The downgradient extent of contamination in the ground water of the bedrock sandstones is unknown However, hydraulic conductivity and gradient data suggest a maximum travel distance of 2250 feet using a maximum calculated gradient of 0 09 ft/ft Additional drilling is required to determine the extent and continuity of these sandstones and of contamination

2 2 3 Surface Water

Twenty-six surface water and surface seep samples in the vicinity of the 903 Pad, Mound, and East Trenches Areas were collected during field activities Some of these samples contained VOCs The most contaminated samples appear to be located just north of the Mound Area and south of the 903 Pad Area Maximum concentrations of TCE, PCE, 1,1-DCE, $CHCl_3$, CCl_4, and 1,1,1-TCE in the upper South Walnut Creek drainage north of the Mound were 62, 73, 133, 40, 605, and 33 ug/l, respectively Other VOCs were not detected Maximum concentrations of TCE, PCE, 1,1-DCE, $CHCl_3$, and CCl_4 in the seeps just southeast of the 903 Drum Storage Site were 40, 65, 140, 84, and 1005 ug/l, respectively However, the samples collected farther downstream on Woman Creek and South Walnut Creek showed no VOC contamination For example, no VOCs were detected in surface water samples from the South Interceptor Ditch (Sample SW-30), Pond C-1 (Sample SW-29), Pond B-5 (Sample SW-B5), and South Walnut Creek (Sample SW-25) VOCs were also not present in seeps northwest of Pond C-2 Thus, VOC contamination of surface water appears to be localized in the immediate vicinity of the 903 Pad and Mound Areas

High plutonium and americium concentrations found in the seeps southeast of the 903 Drum Storage Site represent particulate forms of these radionuclides originating from contaminated soils at the surface This is concluded because

1) the seeps represent surfacing ground water and ground water does not appear to be contaminated with radionuclides,

2) the seep samples contained substantial suspended solids and were not filtered prior to analysis, and

3) surface soils are contaminated with plutonium in the vicinity of these seeps

Filtered and unfiltered surface water samples will be collected from the seeps during the Phase II RI to test the conclusion that the radionuclides in the samples originate from contaminated surficial soils

Data from stations SW-C1 (Pond C-1), SW-29, and SW-28, all located downstream of the 903 Pad on Woman Creek, do not show any indication of radionuclide concentrations elevated above background At station SW-25 on South Walnut Creek downstream of its southern tributary (Central Avenue Ditch), 1986 data also do not indicate any elevated radionuclide concentrations above background

2 2 4 Sediments

Sediment samples were collected during the 1986 initial site characterization from creeks and ditches that traverse the Rocky Flats Plant Except for the presence of what appears to be laboratory introduced contamination (acetone and methylene chloride), HSL organics were not detected in the sediment samples along Woman and South Walnut Creeks The distribution of radionuclides is discussed below

Woman Creek

Plutonium concentrations in the sediments at SED-1 and SED-2 on Woman Creek and its tributary were 0 06(0 02) and 0 80(0 09) pCi/g SED-2 is located on an ephemeral stream due north of Woman Creek, which drains the East Trenches Areas The concentrations at SED-1 and SED-2 are similar to those reported for soils in this vicinity (Rockwell International, 1987a), implying that plutonium concentrations are due to resuspension and settling of contaminated dust from the 903 Pad Area Surface water stations at SED-1 (SW-1) and SED-2 (SW-2) were both dry at the time sediment samples were collected

South Walnut Creek

Plutonium and americium concentrations (in pCi/l) in sediments on South Walnut Creek were as follows

Station	Plutonium	Americium
SED-11	0 02 ± 0 02	0 02 ± 0 02
SED-12	0 35 ± 0 06	0 19 ± 0 05
SED-13	0 07 ± 0 04	0 03 ± 0 03
SED-3	1 9 ± 0 1	0 42 ± 0 06

SED-3 is at Indiana Street downstream of the confluence of North and South Walnut Creeks The plutonium and americium in the sediments may result from windblown dust from the 903 Pad Area Additional sediment samples will be collected to confirm these data and to identify the source of radionuclides

2 2 5 Air

The 903 Pad Area is recognized as the principal source of airborne plutonium contamination at the Plant An extensive air monitoring network known as the Radioactive Ambient Air Monitoring Program (RAAMP) is maintained at the Plant in order to monitor particulate emissions from the 903 Pad Area and other plant facilities Historically, the particulate samplers located immediately east, southeast, and northeast of the 903 Pad, Mound, and East Trenches Areas have shown the highest plutonium concentrations This finding is corroborated by the results of soil surveys which indicate elevated plutonium concentrations to the east, particularly the southeast of the area However, the RAAMP has found ambient air samples to be well within applicable regulations and guidelines for the protection of human health and the environment for all radioactive contaminants that could possibly have originated from the 903 Pad Area

2 2 6 Biota

A series of biota characterization reports have been prepared that are summarized in Rockwell International (1986f) These studies indicate that the majority of the plutonium is tied up in soils and sediments and that it is not transported by biological means However, the studies are currently being reviewed and additional investigations will be performed if necessary

2 3 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that Fund-financed, enforcement, and Federal facility remedial actions comply with applicable or relevant and appropriate (ARAR) Federal laws, or more stringent promulgated State laws

Health-based, chemical-specific ARARs pertinent to ground-water quality have been identified and screened for the HSL organic and inorganic compounds found above detectable levels Radionuclides and conventional pollutants have also been identified and screened Potential ARARs include applicable standards for the protection of ground water promulgated under the Colorado Water Quality Control Act, relevant and appropriate standards associated with the Clean Water Act, and applicable standards defined by the Safe Drinking Water Act, Underground Injection Program A summary of the chemicals found to exceed ARARs as a result of this screening are presented in Table 2-3 As can be seen in Table 2-3, several metals and most of the VOCs that were analyzed have exceeded chemical-specific ARARs during the period 1986-1987 at some location in the 903 Pad, Mound, and East Trenches Areas This is not to say that releases of these constituents are occurring, for the concentrations of some substances may be due to a past release or to natural geochemical processes However, the listing of Table 2-3 has been presented to identify parameters for which analyses should be made in Phase II The Feasibility Study will evaluate technologies that address these constituents

Table 2-3
CHEMICALS FOUND TO EXCEED ARARS FOR
903 PAD, MOUND AND EAST TRENCHES REMEDIAL ACTIONS

Chemicals Exceeding ARARS	Upper Range Downgradient Wells 903 Pad Mound Alluvial	Upper Range Downgradient Wells East Trenches Bedrock	Proposed or Existing Standards	Applicable, Relevant and Appropriate or To be Considered	Standard Criteria or Guidance	Citation	Comment
Copper	0 006 - 0 423 mg/l	0 006 0 016 mg/l	0 2 mg/l	TBC	Potential ARAR is CDH ground water agricultural standard	5 CCR 1002-8 Section 3 11 5	CDH agricultural ground water standard is more restrictive than human health standard Ground water is not classified, therefore, standard is not ARAR
Iron	0 008 - 53 4 mg/l	0 013 53 4 mg/l	0 3 mg/l	TBC	Potential ARAR is CDH ground water human health standard	5 CCR 1002 8, Section 3 11 5	Ground water is not classified, therefore, standard is not ARAR
Manganese	0 005 3 91 mg/l	0 006 - 0 80 mg/l	0 05 mg/l	TBC	Potential ARAR is CDH human health ground water standard	5 CCR 1002 8 Section 3 11 5 dissolved concentration	Ground water is not classified, therefore standard is not ARAR
Mercury	0 00024 0 013 mg/l	0 0001 - 0 0017 mg/l	0 002 mg/l	TBC	Potential ARAR is CDH human health ground water standard	5 CCR 1002-8 Section 3 11 5	Ground water is not classified, therefore standard is not ARAR
Molybdenum	0 024 - 0 192 mg/l	0 023 - 0 192 mg/l	0 1 mg/l	TBC	Potential ARAR is CDH agricultural ground water standard	5 CCR 1002-8 Section 3 11 5	No human health protection standard CDH agricultural ground water standard is applicable to ground water in the state of Colorado Ground water is not classified, therefore, standard is not ARAR
Nickel	0 037 - 0 687 mg/l	0 047 - 0 108 mg/l	0 2 mg/l	TBC	Potential ARAR is CDH agricultural ground water standard	5 CCR 1002 8 Section 3 11 5	No human health protection standard Ground water is not classified, therefore standard is not ARAR
Selenium	0 0028 - 0 036 mg/l	0 005 0 036 mg/l	0 01 mg/l	TBC	Potential ARAR is CDH human health ground water standard	5 CCR 1002-8 Section 3 11 5 dissolved concentration	Human health ground water standard is more restrictive than agricultural standard Ground water is not classified, therefore, standard is not ARAR
Thallium	NR	NR - 0 039 mg/l	0 015 mg/l	TBC	Potential ARAR is CDH water quality limited standard	5 CCR 1002-8 Section 3 1 7 Table 3	Water quality limited standard is not applicable or relevant and appropriate, however it should be considered

CHEMICALS FOUND TO EXCEED ARARS FOR
903 PAD MOUND AND EAST TRENCHES REMEDIAL ACTIONS

Chemicals Exceeding ARARS	Upper Range Downgradient Wells 903 Pad Mound, East Trenches Alluvial	Bedrock	Proposed or Existing Standard	Applicable Relevant and Appropriate or To be Considered	Standard Criteria or Guidance	Citation	Comment
Zinc	0 02 - 2 55 mg/l	0 02 - 0 08 mg/l	2 0 mg/l	TBC	Potential ARAR is CDH agricultural ground water standard	5 CCR 1002-8 Section 3 11 5	Potential ARAR is exceeded in alluvial wells CDH agricultural standard is more restrictive than human health standard Ground water is not classified, there fore standard is not ARAR
Cobalt	0 110 - 0 17 mg/l	0 110 0 17 mg/l	0 05 mg/l	TBC	Potential ARAR is CDH agricultural ground water standard	5 CCR 1002 8 Section 3 11 5	No human health standard Ground water is not classified, therefore standard is not ARAR
Vanadium	0 0241 - 0 04 mg/l	0 0243 0 245 mg/l	0 1 mg/l	TBC	Potential ARAR is CDH agricultural ground water standard	5 CCR 1002 8 Section 3 11 5	No human health standard Ground water is not classified, therefore standard is not ARAR
Carbon Tetrachloride	1 - 4835 ug/l	6 - 3687 ug/l	5 ug/l	R&A	ARAR is the SDWA MCL	40 CFR Part 141 50	Proposed CDH standards are not ARAR
1 1 Dichloro ethene	8 - 673 ug/l	1 - 1044 ug/l	7 ug/l	R&A	ARAR is the SDWA MCL	40 CFR Part 141 50	Proposed CDH standards are not ARAR
Chloroform	1 - 1525 ug/l	5 - 5427 ug/l	100 ug/l	TBC	Potential ARAR is the SDWA MCL	40 CFR Part 141 50	Proposed MCL for chloroform is TBC
1 2 Dichloro ethane	6 - 400 ug/l	24 - 400 ug/l	5 ug/l	R&A	ARAR is the SDWA MCL	40 CFR Part 141 50	Proposed CDH standards are not ARAR

CHEMICALS FOUND TO EXCEED ARARS FOR
903 PAD MOUND AND EAST TRENCHES REMEDIAL ACTIONS

Chemicals Exceeding ARARS	Upper Range Downgradient Wells 903 Pad Mound East Trenches Alluvial	Bedrock	Proposed or Exisiting Standard	Applicable Relevant and Appropriate or To be Considered	Standard Criteria or Guidance	Citation	Comment
t-1 2 Dichloro-ethene	3 1600 ug/l	2 346 ug/l	0 03 ug/l	TBC	Potential ARAR is the CDH proposed ground water std	5 CCR 1002-8 Section 3 11 5	Federal AWQC for the protection of aquatic life is not protective of human health, therefore the CDH proposed standard is TBC
Methylene Chloride	3 240 ug/l	1 - 119 ug/l	5 ug/l	TBC	Potential ARAR is the EPA drinking water health advisory		No promulgated standards
Tetrachloro ethene	4 - 528 000 ug/l	1 4654 ug/l	0 8 ug/l	TBC	Potential ARAR is the CDH proposed ground water std	5 CCR 1002 8 Section 3 11 5	No promulgated standards therefore the CDH pro posed ground water standard is TBC
1 1,1 Tri chloroethane	4 - 2892 ug/l	4 2892 ug/l	200 ug/l	R&A	ARAR is SDWA MCL	40 CFR 141 50	SDWA MCL and proposed state standards are equivalent
Trichloroethene	3 - 28,800 ug/l	3 - 118 298 ug/l	5 ug/l	R&A	ARAR is SDWA MCL	40 CFR 141 50	SDWA MCL and proposed state standards are equivalent
Vinyl Chloride	NR - 790 ug/l	NR - 2 ug/l	2 ug/l	R&A	ARAR is SDWA MCL	40 CFR 141 61	
Gross Alpha	4 - 371 pCi/l	-6 - 350 pCi/l	15 pCi/l	R&A	ARAR is SDWA MCL	40 CFR Part 141 26 (b)(1)(i)	The standard applies to public drinking water supplies but is R&A for ground water Note that the range of analytical values does not in clude the counting error associated with individual analyses

CHEMICALS FOUND TO EXCEED ARARS FOR
903 PAD MOUND AND EAST TRENCHES REMEDIAL ACTIONS

Chemicals Exceeding ARARS	Upper Range Downgradient Wells 903 Pad Mound East Trenches Alluvial	Bedrock	Proposed or Existing Standard	Applicable Relevant and Appropriate or To be Considered	Standard Criteria or Guidance	Citation	Comment
Gross Beta	-19 - 1000 pCi/l	-19 - 1000 pCi/l	50 pCi/l	R&A	ARAR is the SDWA MCL	40 CFR Part 141 26 (b)(1)(i)	The standard applies to public drinking water supplies but is R&A for ground water Note that the range of analytical values does not include the counting error associated with individual analyses
$Pu^{238\ 239\ 240}$	-0 32 32 pCi/l	0 23 32 pCi/l	15 pCi/l 40 pCi/l	TBC TBC	Potential ARAR is CDH ground water standard Potential ARAR is the proposed SDWA MCL	5 CCR 1002 8 Section 3 11 5 51 FR 34859 Sept 30 1986	Ground water is not classified, therefore, CDH standard is not ARAR The proposed SDWA standard is the value in drinking water yielding a risk equal to that from a dose rate of 4 mrem/yr Note that the range of analytical values does not include the counting error associated with the individual analyses
$Americium^{241}$	-0 04 4 4 pCi/l	-0 04 4 4 pCi/l	4 pCi/l	TBC	Potential ARAR is the proposed SDWA MCL	51 FR 34859 Sept 30 1986	The proposed SDWA standard is the value in drinking water yielding a risk equal to that from a dose rate of of 4 mrem/yr
$Strontium^{90}$	0 55 - 9 2 pCi/l	0 55 - 3 8 pCi/l	8 pCi/l	TBC	Potential ARAR is CDH ground water standard	5 CCR 1002-8 Section 3 11 5	Groundwater is not classified, therefore standard is not ARAR
$Uranium^{total}$	0 07 63 9 pCi/l	0 00 - 63 9 pCi/l	40 pCi/l	TBC	Potential ARAR is CDH surface water standard	5 CCR 1002-8 Section 3 8 5(3)	Range of reported values includes Uranium 233 234, 235 and 238
pH	6 5 10 3 units	6 5 - 10 7 units	6 5 - 8 5 units	TBC	Potential ARAR is CDH ground water standard	5 CCR 1002-8 Section 3 11 5	Standard is set to protect domestic ground water use Ground water is not classified, therefore standard is not ARAR

CHEMICALS FOUND TO EXCEED ARARS FOR
903 PAD MOUND AND EAST TRENCHES REMEDIAL ACTIONS

Chemicals Exceeding ARARS	Upper Range Downgradient Wells 903 Pad, Mound Alluvial	East Trenches Bedrock	Proposed for Existing Standard	Applicable Relevant and Appropriate or To be Considered	Standard Criteria or Guidance	Citation	Comment
Chloride	16 - 947 mg/l	3 7 - 358 mg/l	250 mg/l	TBC	Potential ARAR is CDH ground water standard	5 CCR 1002 8 Section 3 11 5	Standard is set to protect domestic use of ground water Ground water is not classified, therefore standard is not ARAR
Sulfate	12 850 mg/l	12 1000 mg/l	250 mg/l	TBC	Potential ARAR is CDH ground water standard	5 CCR 1002 8 Section 3 11 5	Standard is set to protect domestic use of ground water Ground water is not classified, therefore standard is not ARAR
Total Dissolved Solids	26 2662 mg/l	118 - 1813 mg/l	400 mg/l	TBC	Potential ARAR is CDH ground water standard	5 CCR 1002 8 Section 3 11 5(8)(4)	The identified standard applies directly to ground water quality in areas classified as domestic use quality Ground water is not classified, therefore standard is not ARAR

Some chemicals may appear to exceed standards based on thjir observed ranges, however there is insufficient information to evaluate exceedance A list of these chemicals for the 903 pad mound and east trenches area is presented below

Chemical	Information Needed to Evaluate ARAR Exceedance
trivalent chromium	Analyses have been performed for total chromium Need trivalent chromium or hexavalent chromium data
hexavalent chromium	Analyses have been performed for total chromium Need trivalent chromium or hexavalent chromium data
nitrite/nitrate nitrogen	Analyses have been performed on total nitrite/nitrate nitrogen Need to analyze for each individually
cyanide(free)	Analyses have been performed for total cyanide Need to analyze for free cyanide also

3 0 DATA QUALITY OBJECTIVES

The objectives of conducting the remedial investigation are to characterize waste sources, define the nature and extent of contamination, characterize pathways for contaminant migration, determine public exposure (or potential for exposure) to contaminants and associated health risks, assess compliance with ARARs, and satisfy data requirements for selecting a cost effective remedial alternative that is protective of the public health These objectives will be satisfied by

1) collection of a sufficient number of samples in time and space in soils, water, and air for subsequent chemical analysis,

2) drilling a sufficient number of boreholes and conducting appropriate geologic tests,

3) analyzing samples for chemical parameters that indicate site-specific contamination,

4) using analytical methods with detection limits below or near chemical-specific ARARs (Table 3-1), and

5) adhering to a rigorous quality assurance/quality control (QA/QC) plan

Items 1 through 4 are the subjects of Sections 4 and 5 Data collected to characterize background water quality will be inadequate for some time to establish temporal trends or show statistically significant differences between site-related and background conditions However, it will be adequate to conduct a risk assessment and define the extent of contamination exceeding chemical-specific ARARs

TABLE 3-1

COMPARISON OF CHEMICAL-SPECIFIC ARARS
AND TBCs TO ANALYTICAL DETECTION LIMITS

ANALYTE	ARAR OR TBC	DETECTION LIMIT
Copper	0 2 mg/l	025 mg/l
Iron	0 3 mg/l	1 mg/l
Manganese	0 05 mg/l	015 mg/l
Mercury	0 002 mg/l	0002 mg/l
Molybdenum	0 1 mg/l	04 mg/l
Nickel	0 2 mg/l	04 mg/l
Selenium	0 01 mg/l	005 mg/l
Thallium	0 015 mg/l	01 mg/l
Zinc	2 0 mg/l	02 mg/l
Cobalt	0 05 mg/l	05 mg/l
Vanadium	0 1 mg/l	05 mg/l
Carbon Tetrachloride	5 ug/l	5 ug/l
1,1-Dichloro-ethene	7 ug/l	5 ug/l
Chloroform	100 ug/l	5 ug/l
1,2-Dichloro-ethane	5 ug/l	5 ug/l
t-1,2-Dichloro-ethene	0 03 ug/l	5 ug/l*
Methylene Chloride	5 ug/l	5 ug/l*
Tetrachloro-ethene	0 8 ug/l	5 ug/l*

TABLE 3-1

COMPARISON OF CHEMICAL-SPECIFIC ARARS
AND TBCs TO ANALYTICAL DETECTION LIMITS
(CONTINUED)

ANALYTE	ARAR OR TBC	DETECTION LIMIT
1,1,1-Tri-chloroethane	200 ug/l	5 ug/l
Trichloroethene	5 ug/l	5 ug/l
Vinyl Chloride	2 ug/l	10 ug/l*
Gross Alpha	15 pCi/l	2 pCi/l
Gross Beta	50 pCi/l	2 pCi/l
$Pu^{238,239,240}$	15 pCi/l	3 pCi/l
$Americium^{241}$	4 pCi/l	4 pCi/l
$Strontium^{90}$	8 pCi/l	1 pCi/l
$Uranium^{total}$	40 pCi/l	6 pCi/l
Chloride	250 mg/l	5 mg/l
Sulfate	250 mg/l	5 mg/l
Total Dissolved Solids	400 mg/l	5 mg/l

* Detection limit exceeds TBC

TBC = to be considered

With the exception of the 903 Pad, sufficient data already exist for characterization of waste sources These wastes are mixed hazardous and radioactive waste whose composition and volumes are adequately defined They also present unacceptable safety risks for intrusive investigation At the 903 Pad, soil samples will be taken at the perimeter of the pad and characterized with respect to VOC contamination and grain size distribution As discussed in Section 4 1, these data are required to assess remedial action alternatives for this site Although not strictly waste characterization, boreholes are planned for SWMU's 113 and 154 because of revised SWMU locations The data will allow characterization of soil contamination in their immediate vicinity

The highest quality data possible will be collected through adherence to the QA/QC plan, Standard Operating Procedures (SOPs) for conducting field investigations, the Data Management Plan, and the Sampling and Analysis Plan (Sections 4 and 5) Organic and metal analyses will be performed using Contract Laboratory Program (CLP) routine analytical services (RAS) Other analyses will be performed in accordance with the QA/QC plan specified methods

4 0 PHASE II RI SAMPLING LOCATIONS AND RATIONALE

Data requirements were developed for Phase II of the 903 Pad, Mound, and East Trenches Areas RI through review of the draft RI report and EPA's comments on that report Based on the original objectives of the RI, gaps were identified and data requirements were defined in order to meet these objectives Presented below are summary tables of site-specific data objectives and needs organized by data type (Tables 4-1, 4-2, and 4-3) A discussion of sampling locations and rationale based on site-specific data objectives follows the summary tables Section 5 0 describes sampling and analysis methods to meet defined data quality objectives

4 1 SOURCE AND SURROUNDING SOILS CHARACTERIZATION

Several sites included in this remedial investigation program require additional borehole sampling to define the vertical and horizontal extent of soil contamination These are discussed individually below In addit.on, surficial soil samples and vertical plutonium profiles in soils are required in all areas to define the lateral and vertical extent of radionuclide soil contamination This sampling effort is discussed under the 903 Drum Storage Site and Lip Area Site

As shown in Table 4-4, organic contamination of soils is generally well below health-based or technology-based (for treatment) crit ria The health-based criteria were developed based on the exposure and risk rationale provided in the draft 881 Hillside Area Feasibility Study (Rockwell International, 1988b) Soil contaminant concentrations at the 903 Pad, Mound, and East Trenches Areas never exceed these

TABLE 4-1

SOURCE AND SURROUNDING SOILS CHARACTERIZATION OBJECTIVES

Site	Data Objective	Data Need
903 Drum Storage Site	Define depth and lateral extent of plutonium and americium contamination in surficial soils (due wind dispersion)	Plutonium/americium surficial soil scrapes and vertical profiles in the soil at 903 Pad, Mound, and East Trenches Areas
	Determine grain size of materials for soil washing technology	Grain size analyses of borehole samples from edge of 903 pad
Trench T-2	Determine extent of solvents identified in BH25-87	Solvent profiles in boreholes around trench
Mound Site	Characterize revised SWMU location	Contaminant profiles in soils at revised location
Pallet Burn Site	Characterize revised SWMU location	Contaminant profile in soil at revised location

TABLE 4-2

HYDROGEOLOGY AND GROUND-WATER QUALITY DATA OBJECTIVES

Site	Data Objective	Data Need
903 Pad Area	1) Continuity of SS between 9-87BR and 16-87BR	Drill to anticipated horizon and complete well
	2) Extent of saturation/ volatile organic contamination adjacent to 903 Pad Flow directions beneath 903 Pad	Install 5 alluvial wells around Pad
	3) Hydrogeologic conditions at wells 1-71 and 2-71	Replace with two new alluvial wells
	4) Hydrogeologic conditions downgradient of 903 Pad in Rocky Flats Alluvium	Additional alluvial well west of 26-87
	5) Extent of volatile organics in unconfined flow system	New wells at edge of plume based on soil gas and existing wells
	6) Extent of elevated U, SO_4 and TDS in Woman Creek valley fill alluvium	Additional alluvial wells up and downgradient of 65-86
	7) Extent of sandstone and volatile organic contamination in wells 11-87BR, 12-87BR, and 14-87BR	Additional side and downgradient bedrock wells based on projection of sandstone
	8) Relationship between ground water in surficial materials and South Interceptor Ditch	Alluvial wells paired--one on each side of berm where site access allows

TABLE 4-2
(CONTINUED)
HYDROGEOLOGY AND GROUND-WATER QUALITY DATA OBJECTIVES

Site	Data Objective	Data Need
Mound Area	1) Characterize alluvial and bedrock water quality immediately upgradient of area as 43-86 and 23-87BR are influenced by 903 Pad Area	New upgradient well pair
	2) Extent of volatile organics in unconfined flow system	New alluvial wells downgradient to the north and east
	3) Extent of sandstones and volatile organics in well 25-87BR	Additional up and downgradient bedrock wells based on projection of sandstone
East Trenches Area	1) Extent of volatile organics detected in well 3-74	Downgradient alluvial wells north of East Trenches Area and new alluvial well to replace well 3-74
	2) Hydrogeologic conditions in Rocky Flats Alluvium east of northern trenches and north of east access road	Additional alluvial wells north of east access road
	3) Ground-water flow directions and extent of volatile organics in Rocky Flats Alluvium south of southern trenches (T-5 through T-9)	Additional alluvial monitor wells south and east of T-5 through T-9
	4) Extent of sandstone and volatile organics detected in well 36-87BR	Additional side and downgradient bedrock wells based on projection of sandstone
	5) Extent of sandstone and volatile organics detected in well 40-86--also subcrop location	Additional up and downgradient bedrock wells

TABLE 4-3

SURFACE WATER AND SEDIMENT DATA OBJECTIVES

	Data Objective	Data Need
1	Determine source of elevated radionuclides in ground-water seeps	- Filtered and unfiltered samples - at surface water stations
2	Determine source of elevated radionuclides in surface water and sediment samples	- Filtered and unfiltered surface water samples - Sediment sampling at surface water stations in channels of South Walnut and Woman Creeks

TABLE 4-4

COMPARISON OF SOIL CONTAMINANT CONCENTRATIONS TO TECHNOLOGY-BASED AND HEALTH-BASED CRITERIA

Contaminant	LDR* (ug/kg)	Risk Assessment Based** Acceptable Concentration (ug/kg)	Maximum Concentration in Soils (ug/kg)
Acetone	11,800		2,400
Carbon Tetrachloride	19,200	7,920	100
Methylene Chloride	19,200		210
Methyl Ethyl Ketone	15,000		150
Tetrachloroethene	1,000	20,200	<u>10,000</u>
Toluene	6,600		640
1,1,1 Trichloroethane	8,200		180
Trichloroethene	1,820	93,800	<u>16,000</u>
Xylene	3,000		<u>3,300</u>
Bis(2 ethylhexyl)phthalate		1,500,000	18,000
1,2 Dichloroethane		11,300	120
Ethyl Benzene	1,060		780

*LDR = Land Disposal Restriction For F001 F005 wastes, assuming 100% extraction (20 1 extract wt soil wt), these concentrations cannot be exceeded in the soils if they are land disposed These limits are considered achievable by treatment of the soils prior to disposal

**Computed based on exposure from dust inhalation, dermal contact, and soil ingestion, and a 10^{6} incremental cancer risk See 881 Hillside Feasibility Study (Rockwell International, 1988b) for exposure estimates and carcinogenic potency factors

NOTE Underline indicates concentration of soil is above levels that can be achieved by soil treatment These all occurred in borehole BH25 87 No contaminants exceeded the health based criteria

criteria As shown in Table 4-4, only soils at borehole 25-87 (Trench T-2) exceeded the technology-based criteria which are adapted from the Land Ban restrictions for hazardous waste (40 CFR 268) Therefore, only at this location will further soil samples be collected to characterize the extent of contamination for purposes of evaluating soil treatment technologies which may reduce the time required for ground-water treatment Other soil sampling locations are based on the need to investigate a SWMU because its location was revised during the Phase I RI

4 2 1 903 Pad Area

4 2 1 1 903 Drum Storage Site and Lip Area Site

Surficial Soil Sampling

Plutonium was elevated above background levels in boreholes from several sites in the 903 Pad, Mound, and East Trenches Areas However, radionuclide contamination is limited to the uppermost soil samples from each borehole In order to characterize the vertical and horizontal extent of surficial soil plutonium contamination, surficial soil scrapes and vertical soil profiles will be collected in all three remedial investigation areas and in the Plant areas (buffer zone) south and east of these areas to Indiana Street

In addition to the RI data, Rockwell conducts annual soil sampling to assess plutonium contamination in soils surrounding the 903 Pad The Rocky Flats Plant site soil sampling procedures are designed to assess total plutonium in the soil A 10 centimeter (cm) x 10 cm frame is driven 5 cm into the soil Material within the frame is collected Ten subsamples are collected from an area approximately three meters x one meter Samples are collected annually on one and two mile intervals from points located on 18 degree radii from Plant center Soil is collected from approximately the same point each year Figure 4-1 is a map showing soil plutonium concentrations at the sample points averaged over the years 1984-1987

Extensive sampling has also occurred off site Off-site soil sampling is outside the scope of this investigation Off-site soil contamination is undergoing remedial action as a separate project which is described in Rockwell International (1988c)

In order to assess the extent of plutonium in surficial soils within Plant boundaries, soil samples will be collected across the area identified in Figure 4-2 This delineation is based on results depicted in Figure 4-1 Figure 4-1 shows the composited results of Rocky Flats Plant annual sampling from 1984-1987 Figure 4-2 was constructed by including all areas where soil plutonium concentrations are expected to exceed 2 disintegrations per minute per gram (d/m/g) A narrow buffer zone was added, however, if sampling indicates the zone needs to be expanded, further sampling will be done to properly delineate the area This area consists of approximately 800 acres The Colorado Department of Health plutonium in soil standard will be used as the target value The state has adopted special construction technique requirements for lands with plutonium concentrations greater than 2 disintegrations per minute per gram (dpm/g) of soil which is approximately equal to 1 pCi/g This concentration level is far below the proposed EPA screening level of 20 pCi/g (EPA, 1977) This is a conservative standard which is already in use The standard is 2 d/m/g of dry soil (approximately one picocurie per gram of dry soil) To assess the soil plutonium values in reference to this standard, the CDH sampling protocol will be used

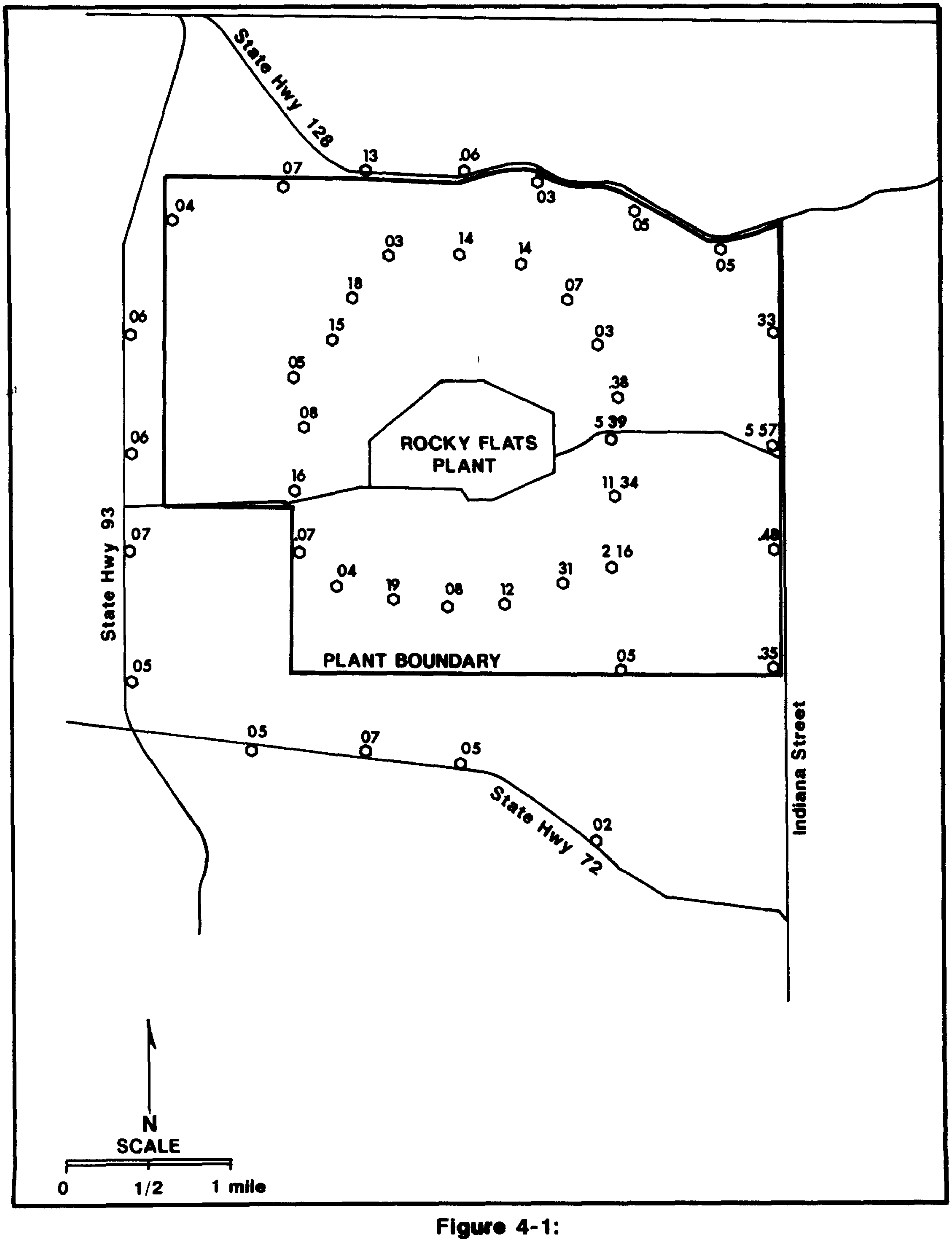


Figure 4-1:

PLUTONIUM CONCENTRATIONS IN SOIL (Values in Picocuries per Gram)

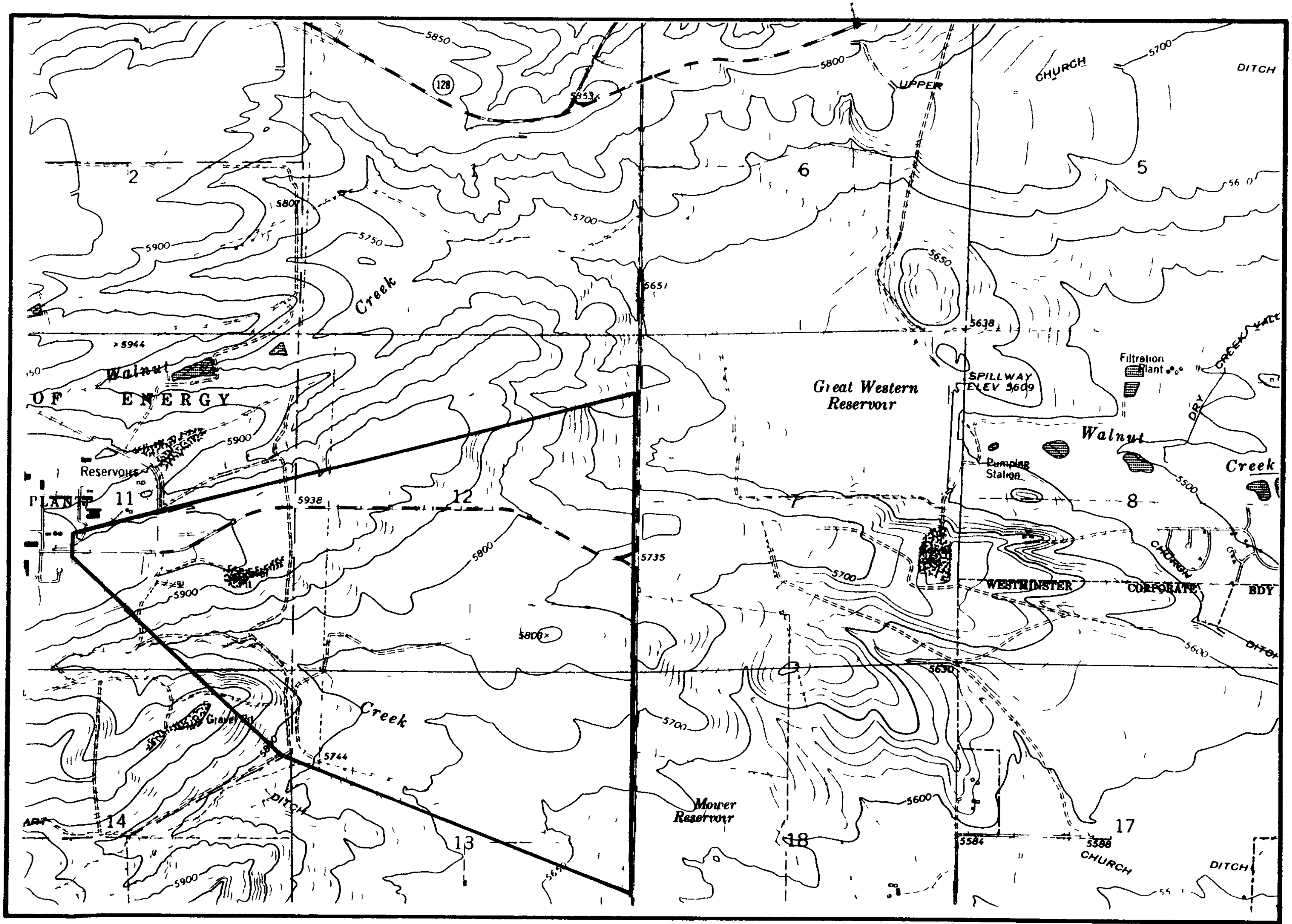


Figure 4-2:
ESTIMATED MAXIMUM EXTENT OF SOILS CONTAINING 2 d/m/g PLUTONIUM BY CDH PROTOCOL

The 10-acre grids will be located as indicated on Figure 4-3 Grids will not be contiguous except near the 903 Pad Lines of grids will be placed to define the southern and northern extent of contamination Other grids will be used to confirm values from within the areas of concern The northwest corner of each grid will be located by survey and identified with an appropriately marked steel post Grids will be oriented on the cardinal compass directions The 25 subsamples will be located with a handheld compass and tape measure using the northwest corner as the starting point

In order to assess the vertical distribution of plutonium in the soil profile, subsurface sampling will also be done Figure 4-4 shows the locations of the 24 points where soil profiles will be sampled These locations will describe the plutonium distribution in the profile from high to low concentration areas, allowing mapping of concentration with depth Backhoe pits will be excavated at each of the indicated locations to a depth of one meter A 1/8 inch surface scrape, 1 8 inch to 1 centimeter deep sample, and 1 cm to 5 centimeter deep sample will be taken Samples will then be collected each 50 to 100 centimeters Samples will be collected from the face of the pit, with all samples being collected within 50 centimeters of each other horizontally The samples will be collected from the bottom upward to the surface Equipment will be decontaminated between collection of each sample Samples will also be collected for particle size analysis

All samples will be analyzed according to approved Colorado Department of Health procedures Particle size analysis shall be done according to standard sieve analysis methodology

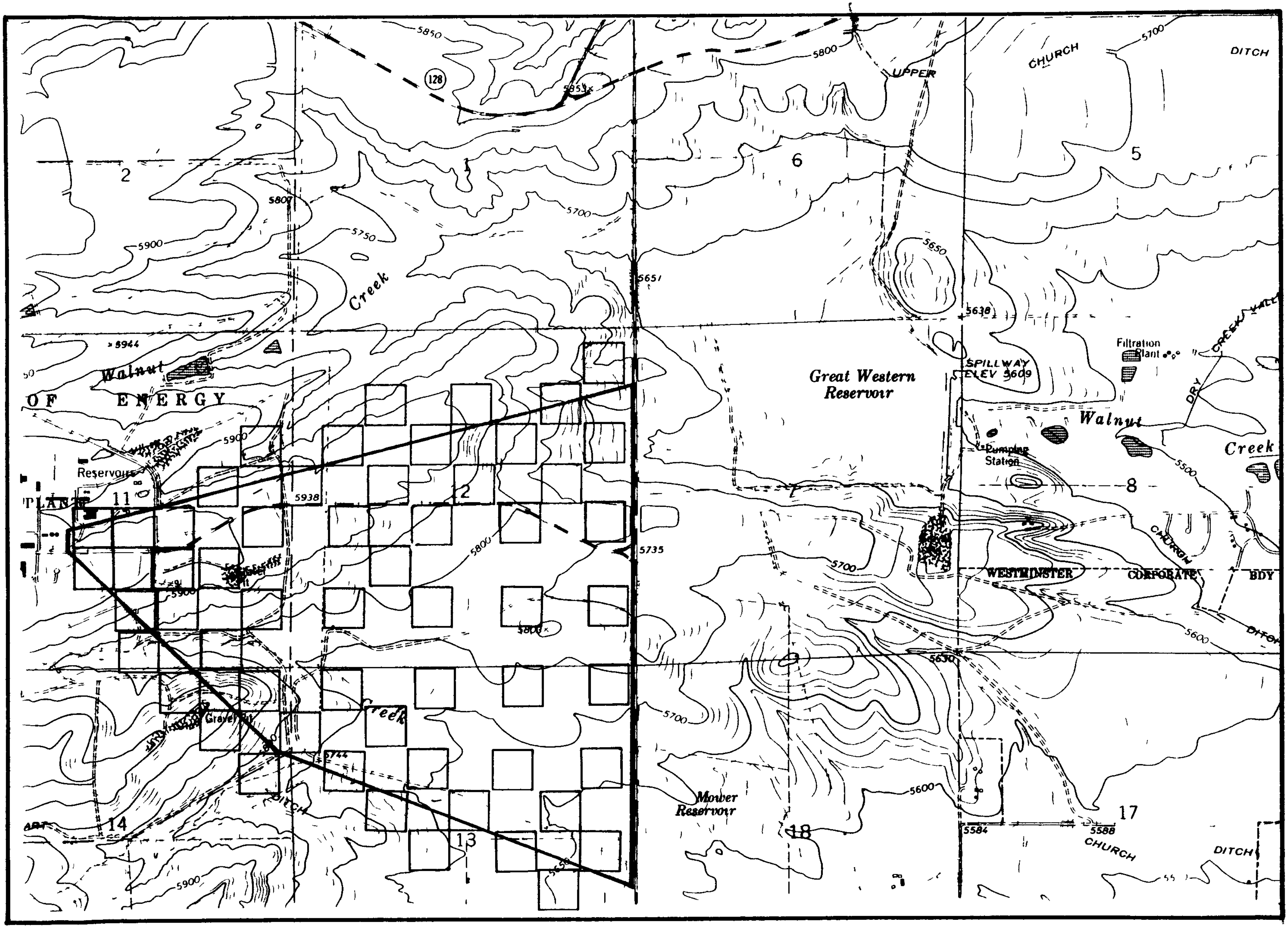


Figure 4-3: 10 ACRE SAMPLING PLOT LOCATIONS

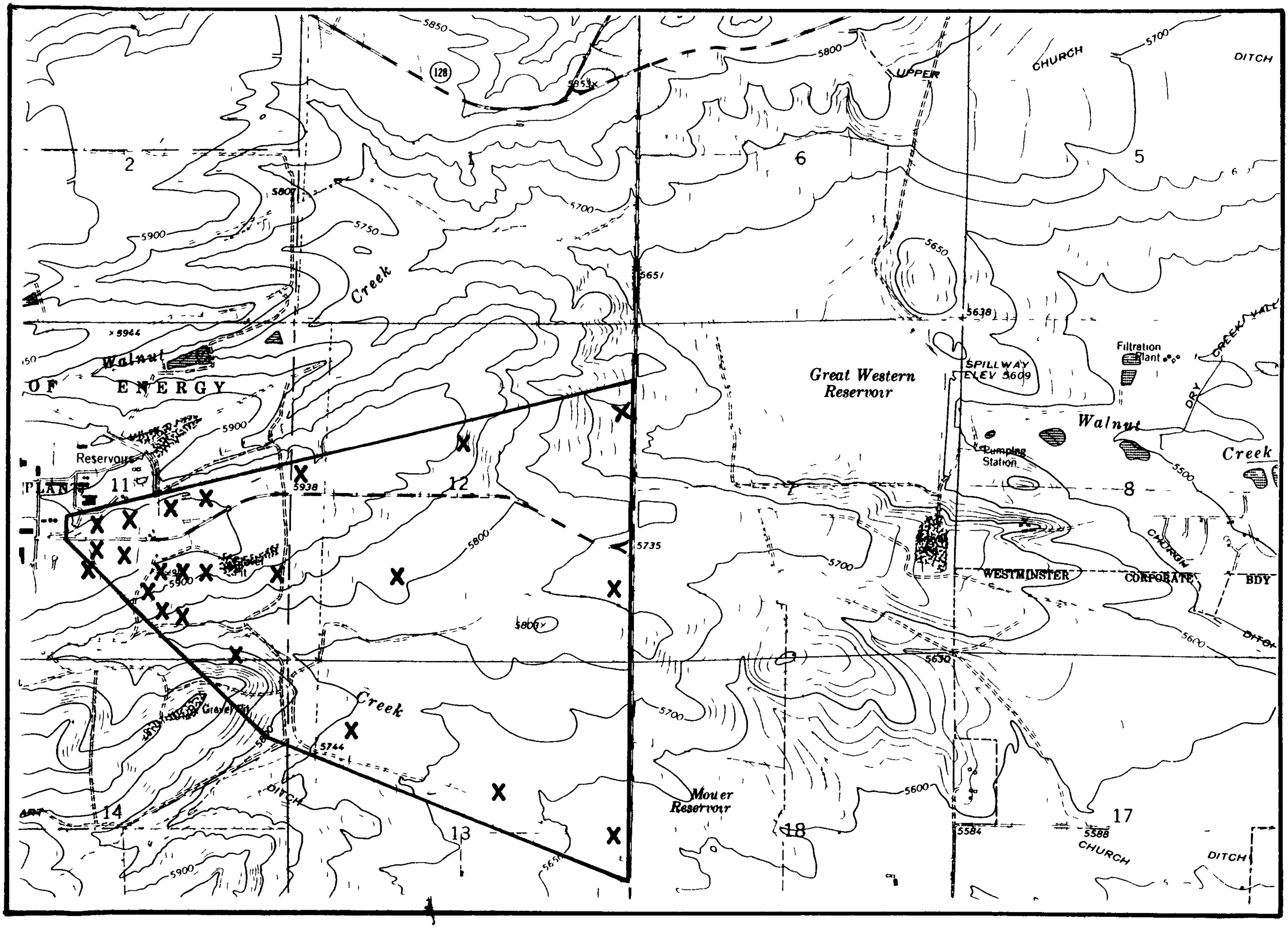


Figure 4-4: SOIL PROFILE SAMPLING LOCATIONS

Borehole Sampling

Five additional boreholes will be drilled and sampled immediately adjacent to the present 903 Pad to evaluate the presence of HSL organics in soils at the site BH1-88 will be located on the west edge of the Pad, BH2-88 on the north edge of the Pad, BH3-88 and BH4-88 on the east side of the Pad, and BH5-88 on the south side of the Pad These boreholes will be completed as alluvial monitor wells to characterize ground-water flow directions and ground-water quality adjacent to the pad

Review of historical data (see Section 1 2 1) indicates up to 34 inches of soils may be contaminated under the pad Additional drilling through the pad to define radionuclide and solvent contamination profiles is not warranted considering the potential health risks, potential equipment and rig contamination problems, and extensive measures required to control dissemination of plutonium-contaminated soils brought to the surface The concentrations of plutonium in soils under the pad will necessitate soil treatment or off-site disposal of the soil as a mixed waste Particle size distribution is a key parameter in estimating the performance of a soil scrubbing plutonium decontamination technology Grain size analysis will therefore be conducted on soils adjacent to the pad to fill this data need Solvent analyses will also be performed on these samples to evaluate the need for treatment of organics in liquid waste streams generated during soil scrubbing

4 2 1 2 Trench T-2

Boreholes BH6-88 through BH11-88 will be drilled and sampled in the vicinity of Trench T-2 to define the extent of volatile organic contamination identified in

BH25-87 Boreholes BH6-88 and BH7-88 will be drilled north (upgradient) of the trench, and BH8-88 will be located west of the trench Boreholes BH9-88 through BH11-88 will be located south of the trench and of BH25-87 to determine the downgradient extent of contamination Boreholes BH6-88, BH9-88, BH10-88, and BH11-88 will also be completed as alluvial monitor wells to characterize ground water up- and downgradient of the site

4 2 2 Mound Area

4 2 2 1 Mound Site

As the location of this site was revised during the Phase I RI, additional boreholes are required to characterize the revised location Two boreholes will be drilled into the revised Mound location Borehole BH12-88 will be located near the center of the SWMU and BH13-88 will be located at the southeast corner of the SWMU The Perimeter Security Zone (PSZ) fence was constructed over the western edge of the Mound Site subsequent to its use Th s fence and associated buried utilities prohibit drilling the western side of this SWMU

4 2 2 2 Pallet Burn Site

The location of the Pallet Burn Site was revised during the Phase I RI A borehole will be located near this revised location to investigate the nature of any contamination BH14-88 will be drilled at the southeast corner of the revised SWMU location

4 3 HYDROGEOLOGIC AND GROUND-WATER QUALITY CHARACTERIZATION

Based on data collected during the Phase I investigation, volatile organics are present in alluvial and bedrock ground-water flow systems at the 903 Pad, Mound, and East Trenches Areas The extent of contamination is not fully delineated, and additional monitor wells are needed to define the vertical and lateral extent of the organics Potential major ion, trace metal, and radionuclide impacts to ground water were not well characterized in the Phase I RI report due to the lack of appropriate background ground-water quality data

Presented below are proposed monitor well locations and rationale to further characterize ground-water flow and quality at the 903 Pad, Mound, and East Trenches Rationale are based on general data quality objectives and site-specific data needs

4 3 1 Unconfined Ground-Water Flow System in Surficial Materials

Based on initial sampling results and the soil gas survey, PCE, CCl_4, and TCE are the primary volatile organic contaminants found in the unconfined ground-water flow system The maximum lateral extent of these contaminants is delineated by wells 64-86, 65-86, 66-86, 67-87, and 36-86, where volatile organics do not occur However, the exact leading edge of the plume is not well defined by the current network of monitoring wells

PCE is the most extensive volatile organic contaminant in ground water at the 903 Pad, Mound, and East Trenches Areas As shown on Plate 2-3, PCE is more extensive in alluvial ground water than is reflected by the soil gas survey Up to 160 ug/l of PCE were detected in well 41-86, while the soil gas survey did not detect any PCE at this location Thus, additional alluvial monitor wells are needed to define the leading plume edge

4 3 1 1 903 Pad Area

A total of 24 new alluvial monitor wells will be completed within and downgradient of the 903 Pad Area Eleven alluvial wells will be completed within the area, and 11 alluvial wells will be completed downgradient Table 4-5 presents the proposed wells, the objective of each well, and anticipated completion intervals

Five new alluvial wells (1-88, 2-88, 4-88, 7-88, and 8-88) are proposed immediately adjacent to the 903 Drum Storage Site to evaluate the extent of saturation, flow directions, and water quality in Rocky Flats Alluvium beneath the pad Wells 9-88, 10-88, 12-88, 14-88, and 15-88 will be drilled downgradient of the 903 Drum Storage Site, Trench T-2, and the Reactive Metal Destruction Site, but will be within the 903 Pad Area These wells will serve to differentiate between these three potential sources of volatile organics Well 12-88 will replace well 2-71, and well 15-88 will replace well 1-71, as well construction details of the 1971 wells are unknown

Eleven new alluvial monitor wells are proposed to further define the lateral extent of PCE in the shallow ground-water system (Plate 2-3) These wells are located to evaluate the extent of saturation and the potentiometric surface while characterizing ground-water quality

Three wells (16-88, 32-88, and 41-88) will be completed in Rocky Flats Alluvium east of the 903 Drum Storage Site to define he extent of PCE in alluvial

Table 4 5

PROPOSED PHASE II ALLUVIAL WELLS 903 PAD, MOUND, AND EAST TRENCHES AREAS

WELL NO	PURPOSE	ANTICIPATED TOTAL DEPTH (feet below g s)	ANTICIPATED SCREENED INTERVAL
<u>903 Pad Area</u>			
1 88	Adjacent to and upgradient of 903 pad	11	3 15
2 88	Adjacent to and downgradient of 903 Pad (north)	15	3 15
4 88	Adjacent to and downgradient of 903 Pad (northeast)	15	3 15
7 88	Adjacent to and downgradient of 903 Pad (southeast)	18	3 18
8 88	Adjacent to and downgradient of 903 Pad (south)	16	3 16
9 88	Downgradient (south) of 903 Pad Upgradient of Trench T 2 (north)	5 10	3 10
10 88	Downgradient of Trench T 2 (south)	5	3 5
12 88	Downgradient (southeast) of Trench T 2 Replace well 2 71	5	3 5
14 88	Downgradient of Reactive Metal Destruction Site	5	3 5
15 88	Downgradient of 903 Pad and Reactive Metal Destruction Site Replace Well 1 71	5	3 5
16 88	Determine Rocky Flats Alluvium thickness Extent of VOC's downgradient (east) of 903 Pad and Mound Areas	25	3 25
21 88 and 22 88	Extent of VOC's downgradient (south) of 903 Pad Area Groundwater/surface water interaction at South Interceptor Ditch	20	3 20
25 88	Extent of VOC's downgradient (southeast) of 903 Pad Area Ground water/surface water interaction at South Interceptor Ditch	20	3 20
26 88	Monitor Woman Creek Valley fill upgradient of 65 86	8	2 5 8

Table 4 5 (continued)

PROPOSED PHASE II ALLUVIAL WELLS 903 PAD, MOUND, AND EAST TRENCHES AREAS

WELL NO	PURPOSE	ANTICIPATED TOTAL DEPTH (feet below g s)	ANTICIPATED SCREENED INTERVAL
27 88 and 28 88	Extent of VOC's downgradient (southeast) of 903 Pad Area Groundwater/surface water interaction at South Interceptor Ditch	20	3 20
29 88	Monitor Woman Creek Valley fill downgradient of 65 86	8	2 5 8
30 88	Extent of VOC's and saturation downgradient (southeast) of 903 Pad	10	3 10
31 88	Same as above	10	3 1
32 88	Determine Rocky Flats Alluvium thickness Extent of VOC's downgradient (east) of 903 Pad and Mound Areas	25	3 25
	Extent of VOC's downgradient (southeast)	5 10	3 10
41 88	Extent of VOC's downgradient (east) of 903 Pad and Mound Areas	25	3 25
<u>Mound Area</u>			
34 88	Upgradient (west) of the Mound Area Extent of VOC's (northwest)	15	3 15
36 88	Downgradient of Mound Area	10	3 10
38 88	Extent of VOC's downgradient (north) of Mound Area	10	3 10
39 88	Extent of VOC's downgradient (east) of Mound Area	25	3 25
40 88	Extent of VOC's downgradient (northeast) of Mound Area	15	3 15
<u>East Trenches Area</u>			
43 88	Extent of VOC's Downgradient (north) of Trench T 3	10	3 10
46 88	Water Quality Adjacent to Trench T 3	20	3 20
49 88	Water Quality Upgradient of Southern East Trenches	30	3 30

Table 4 5 (continued)

PROPOSED PHASE II ALLUVIAL WELLS 903 PAD, MOUND, AND EAST TRENCHES AREAS

WELL NO	PURPOSE	ANTICIPATED TOTAL DEPTH (feet below g s)	ANTICIPATED SCREENED INTERVAL
52 88	Water Quality Adjacent to Trench T 4	25	3 25
44 88	Extent of VOC's downgradient (north) of Trenches T 3 and T 4 in colluvium	10	3 10
45 88	Extent of VOC's downgradient (northeast) of Trenches T 3, T 4, T 10, and T 11 in colluvium	10	3 10
56 88	Extent of saturation and VOC's in the alluvium east of the northern trenches	23	3 23
58 88	Monitor water quality downgradient of the northern trenches and upgradient of the southern trenches	17	3 17
62 88	Water quality south and east of south trenches	35	3 35
63 88	Water quality south and east of south trenches	40	3 40
65 88	Water quality south and east of south trenches	43	3 43
66 88	Water quality south and east of south trenches	43	3 43
72 88	Water quality south and east of south trenches	45	3 45
73 88	Water quality south and east of south trenches	45	3 45
74 88	Water quality north and east of north trenches	45	3 45
75 88	Determine extent of saturation and VOC's in the alluvium east of the northern trenches	45	3 45
76 88	Water quality south of East Trenches Area	15	3 15
77 88	Eastern edge of T 10 to evaluate potential source of VOC	22	3 22
79 88	Replace well 3 74 with monitor water quality north of north trenches	7	3 7

Notes 1) Alluvial wells will be screened over the entire alluvium/colluvium in thickness unless distinct clay layers are identified during drilling

ground water and to characterize alluvial ground-water flow Likewise, alluvial wells 30-88 and 31-88 will be completed in colluvium southeast of the 903 Pad Area for plume delineation Alluvial wells 21-88, 25-88, and 27-88 will be drilled along the northern berm of the South Interceptor Ditch and completed in the berm to monitor the quality of ground water in connection with the ditch Wells 22-88 and 28-88 will be located on the southern berm of the ditch across from 21-88 and 27-88, respectively, to evaluate the relationship between the South Interceptor Ditch and alluvial ground-water flow and quality

No volatile organics have been detected in Woman Creek valley fill alluvium downgradient of the 903 Pad Area in well 65-86 However, chloride, sulfate, and total dissolved solids (TDS) have appeared elevated in this well Two additional wells will be installed in the Woman Creek valley fill alluvium to verify these conclusions and provide additional monitoring of the valley fill alluvium Well 26-88 will be completed in alluvium west (upgradient) of 65-86 and east (downgradient) of Pond C-1, and well 29-88 will be drilled east (downgradient) of 65-86 but west (upgradient) of Pond C-2

4 3 1 2 Mound Area

Five new alluvial monitor wells are proposed for the Mound Area The current upgradient well (43-86) appears to be impacted by the 903 Drum Storage Site, so another upgradient alluvial well is needed Well 34-88 will be installed in Rocky Flats Alluvium west of 43-86 and the 903 Pad Area to serve as an upgradient well

Four downgradient alluvial wells (36-88, 38 88, 39-88, and 40-88) will be completed in colluvium and Rocky Flats alluvium north and east of the Mound Area

These wells will serve to characterize ground-water flow directions and quality away from the area

4 3 1 3 East Trenches Area

Trenches T-3, T-4, T-10, and T-11

Ten new alluvial wells will be drilled within and downgradient of the northern trenches to characterize ground-water quality and flow Well 46-88 will be installed adjacent to Trench T-3 (on the north side) to determine if T-3 is the source of VOCs in well 3-74 Likewise, wells 77-88 and 52-88 will be drilled on the eastern edges of Trenches T-4 and T-10, respectively, to evaluate them as potential sources of VOCs Wells 43-88, 44-88, and 45-88 will be completed in colluvial materials north and northeast of these trenches These wells will serve to evaluate flow paths and ground-water quality north of the trenches Similarly, wells 56-88, 74-88, and 75-88 will help determine the extent of saturation and VOCs in the Rocky Flats Alluvium east of the northern trenches Well 3-74 will be replaced by a new well (79-88) as well construction details of this well are unknown

Trenches T-5 through T-9

An additional nine alluvial wells are proposed downgradient of these southern trenches to further characterize the paleochannel at the Rocky Flats Alluvium base and to try to define the extent of VOCs in alluvial ground water Two additional wells (49-88 and 58-88) will monitor ground water downgradient of the northern trenches and upgradient of the southern trenches, and the remainder of the wells (62-

88, 63-88, 65-88, 66-88, 72-88, and 73-88) will essentially ring the trenches to the east and south

4 3 2 Bedrock Flow System

Several Arapahoe Formation sandstones were encountered beneath surficial materials at the 903 Pad, Mound, and East Trenches Areas during the Phase I remedial investigation These sandstones are estimated to strike roughly north-south and dip approximately 7 degrees to the east, however, further data are needed to support this hypothesis The investigative program is designed on the basis of the estimated orientation of the bedrock units If data generated by the program indicate a different orientation, relocation of some wells may be required In addition, some of the wells completed in these sandstones contain volatile organics, and further data are needed for plume delineation in each sandstone Sandstones requiring further investigation have been assigned letter designations M through Z for discussion purposes The purpose of the Phase II RI bedrock investigation is to further characterize the extent of these sandstones and the volatile organic contaminants therein contained Table 4-6 presents proposed bedrock wells along with anticipated total depths and screened intervals

A seismic geophysical program is being planned as part of the Phase II RI investigation to help determine the extent of Arapahoe sandstones The geophysical program is being implemented in three phases The first phase will include geophysical modelling of the existing geologic data base, and the second phase will consist of acquisition, processing and interpretation of vertical seismic profiles and one or two seismic lines to test the geophysical model If the seismic program proves useful by successfully locating known shallow sandstones during the first two phases

TABLE 4-6
PROPOSED BEDROCK WELLS AT THE 903 PAD, MOUND, AND EAST TRENCH AREAS

WELL NO	PURPOSE	TARGETED SANDSTONE	ANTICIPATED TOTAL DEPTH	ANTICIPATED SCREENED INTERVAL
6 88BR	Continuity and hydraulic gradient in Sandstone Z	Z	75	55 75
5 88BR	Extent and water quality of Sandstone Y	Y	30	25 30
3 88BR	Does Sandstone X subcrop beneath 903 Pad? Monitor ground water quality	X	40	15 40
37 88BR	Monitor ground water quality downgradient of 23 87 Evaluate continuity of sandstone and dip angle	X	58	38 58
17 88BR	Monitor ground water quality downgradient of 12 87BR Dip angle	W	20	12 20
19 88BR and 13 88BR	Monitor ground water quality along subcrop strike Continuity and orientation of sandstone	W W	10 15	70 10 10 15
18 88BR	Monitor ground water quality downgradient of 11 87BR Dip angle	V	20	13 20
81 88BR and 83 88BR	Monitor ground water quality along strike Continuity and orientation of Sandstone V	V	13	7 13
20 88BR	Monitor ground water quality upgradient of 14 87BR Locate subcrop	U	30	23 30
24 88BR	Monitor ground water quality downgradient of 14 87BR Dip angle	U	50	43 50
23 88BR	Monitor ground water quality alaong strike Continuity and orientation of Sandstone U	U	15	8 15
42 88BR and 33 88BR	Continuity, extent and orientation of Sandstone T subcrop Monitor ground water quality along strike	T	45	20 45
53 88BR	Same as above	T	58	20 58
50 88BR	Monitor ground water quality downgradient of 25 87BR Dip angle	T	63	19 63

TABLE 4-6 continued
PROPOSED BEDROCK WELLS AT THE 903 PAD, MOUND, AND EAST TRENCH AREAS

WELL NO	PURPOSE	TARGETED SANDSTONE	ANTICIPATED TOTAL DEPTH	ANTICIPATED SCREENED INTERVAL
47 88BR,	Characterize ground water quality	S	35	25 35
48 88BR, and	Continuity and orientation	S	35	25 35
78 88BR	of Sandstone S	S	25	15 25
54 88BR, and	Extent of sandstone and VOC's	R	50	25 50
51 88BR	in ground water along strike Continuity and orientation of sandstone	R	50	25 50
81 88BR	Same as above	R	27	12 27
55 88BR	Monitor ground water quality downgradient of 36 87BR Dip angle	R	42	17 42
57 88BR	Same as above	R	75	50 75
59 88BR and 60 88BR	Monitor ground water quality at subcrop of Sandstone P Conti nuity and orientation	P	38	15 38
61 88BR	Monitor ground water quality in Sandstone P at 28 87BR location	P	115	95 115
67 088BR	Evaluate continuity and orientation of Sandstone P	P	150	130 150
64 88BR	Same as above	P	130	110 130
70 88BR	Initial evaluation ground water quality in Sandstone O	O	123	110 123
68 88BR	Evaluate lateral extent of VOCs in 40 86 Continuity and orientation of Sandstone N	N	108	88 108
69 88BR	Monitor water quality upgradient of 40 86 Continuity orientation, and lithology of Sandstone N	N	80	70 80
71 88BR	Monitor water quality down gradient of 40 86	N	134	114 134
81 88BR	Initial evaluation of ground water quality in Sandstone M	M	84	76 84

of implementation, a third phase of additional data acquisition, processing, and interpretation will be implemented Based on this program, fewer bedrock monitor wells may be needed

4 3 2 1 903 Pad Area

Sandstones Z, Y, X, W, V, and U subcrop in the 903 Pad Area, and additional wells are needed in each of these sandstone units Proposed bedrock wells are discussed by sandstone unit below

Sandstone Z subcrops west of the 903 Pad Well 9-87BR is completed in the sandstone at its subcrop, and well 16-87BR is completed downdip and downgradient of the 903 Pad No volatile organic contamination has been detected in either well However, an additional bedrock well will be installed in Sandstone Z to determine if indeed it is continuous between wells 9-87BR and 16-87BR and to evaluate the hydraulic gradient This new well (6-88BR) will be located on the east edge of the 903 Pad

Sandstone Y was encountered in well 16-87BR, however, no wells were completed in it If it is continuous to the surface instead of pinching as shown on cross section A-A' (Plate 2-5), it likely subcrops beneath the 903 Pad If Sandstone Y is encountered by well 6-88BR, a bedrock well (5-88BR) will be completed in Sandstone Y east of the 903 Pad to evaluate its water quality

Sandstone X occurs north of the 903 Pad Well 23-87BR is completed in Sandstone X, and well 18-87BR penetrates the same sandstone Two new bedrock wells will be completed in Sandstone X Well 3-88BR will be located on the northern edge of the 903 Pad to determine if Sandstone X subcrops under the pad, and well 37-

88BR will be located due east of 23-87BR to evaluate its continuity and dip angle Both wells will serve to monitor ground-water quality in Sandstone X

In the Phase I RI report, 11-87BR and 12-87BR are shown as being completed in the same sandstone However, reinterpretation of the geologic logs, apparent dip, and water quality data, indicates these two wells are completed in separate sandstones Well 12-87BR is completed in Sandstone W, and well 11-87BR is completed in Sandstone V (Cross Section B-B', Plate 2-5) Thus, additional monitor wells are required for each sandstone

Sandstone W subcrops in the Reactive Metal Destruction Site, and well 12-87BR is completed in this sandstone As volatile organics have been detected in well 12-87BR, four new bedrock wells will be completed in Sandstone W to assess the extent of volatile organic contamination and of the sandstone One well (17-88BR) will be drilled down dip (east) and presumably downgradient of well 12-87BR, and two wells will be drilled along strike of the subcrop to evaluate the extent and orientation of the sandstone (13-88BR and 19-88BR) These wells will serve to monitor ground-water quality and to evaluate hydraulic gradients in Sandstone W If Sandstone W is found continuous with Sandstone V upon completion of 19-88BR, the placement of wells in these two sandstones will be reevaluated

Sandstone V subcrops southeast of Sandstone W, and well 11-87BR is completed in it Volatile organics were detected in this well, so three additional wells will be completed in Sandstone V to evaluate the extent of contaminants and the sandstone unit Well 18-88BR will be installed downdip and presumably downgradient of 11-87BR, and wells 82-88BR and 83-88BR will be completed along strike of the subcrop (north and south of 11-87BR, respectively)

Well 14-87BR is completed in Sandstone U, and volatile organics were detected in this well during the fourth quarter of 1987 Three new wells will be completed in this sandstone unit Well 20-88BR will be located west of 14-87BR to verify the projected subcrop location, and well 24-88BR will be located downdip (and presumably downgradient) of well 14-87BR to assess the extent of contamination Likewise, an additional well will be completed south of 14-87BR (along strike) to evaluate the extent of volatile organics (23-88BR) These wells will help define the orientation of Sandstone U

4 3 2 2 Mound Area

Sandstone X subcrops in the Mound Area between the Pallet Burn Site and Oil Burn Pit No 2, and Sandstone T subcrops east of the Mound Area No subcropping sandstones were found directly beneath the Mound Site New wells to monitor Sandstone X are discussed in Section 4 4 2 1

Well 25-87BR is completed in Sandstone T which subcrops east of the Mound and possibly 903 Pad Areas Volatile organics were detected in this well during the fourth quarter of 1987, indicating the sandstone is recharged by contaminated alluvial ground water from either of these two sources

Four additional bedrock wells will be drilled and completed in Sandstone T to evaluate the extent of volatile organic contamination as well as the extent and orientation of the sandstone Two wells (42-88BR and 33-88BR) will be completed south of 25-87BR, and one well (53-88) will be installed north of 25-87BR, to define the extent of Sandstone T along strike A fourth well (50-88BR) will be completed downdip (presumably downgradient) of well 25-87BR to look for the downgradient edge of volatile organics

4 3 2 3 East Trenches Area

Three subcropping sandstone units (Sandstones S, R, and P) were identified in the East Trenches Area Sandstones S and R subcrop beneath Trenches T-4 and T-11, and Sandstone P subcrops beneath Trench T-9 Sandstones S and R may be interconnected at depth

Sandstone S was encountered by borehole BH44-87 and BH42-87, however, no wells are completed in this unit Three new wells will be completed in this sandstone during the Phase II RI to evaluate its continuity, orientation, potentiometric surface, and water quality Wells 47-88BR, 48-88BR, and 78-88BR will be completed along strike at the eastern edge of the Sandstone S subcrop to determine if this unit is continuous beneath the trenches

Sandstone R was encountered in BH45-87, BH42-87, well 34-87BR, and well 36-87BR Elevated levels of TCE were detected in well 36-87BR, however, the extent of contaminants is unknown Therefore, five bedrock wells will be installed in Sandstone R to evaluate ground-water quality and extent of the sandstone unit Wells 54-88BR and 51-88BR will be completed along strike in the subcrop area south of borehole BH42-87 to locate the southern end of the subcrop, and well 81-88BR will be located north of 36-87BR Well 57-88BR will be completed roughly halfway between BH42-87 and 34-87BR to verify the correlation between these two holes, and well 55-88BR will be installed downgradient (east) of well 36087BR to define the extent of volatile organics in ground water

The projected subcrop of Sandstone P occurs beneath Trench T-9 This unit is penetrated by well 28-87BR, and well 31-87BR is completed in it There are no ground-water quality data available for well 31-87BR at this time

Five bedrock wells will be drilled and completed in Sandstone P to characterize its orientation and ground-water quality Two wells (59-88BR and 60-88BR) will be installed in the subcrop area, north and south of Trench T-9 respectively, to characterize upgradient conditions A third well (61-88BR) will be drilled adjacent to well 28-87BR and completed in Sandstone P Well 67-88BR will be completed downdip (east) of 31-87BR just south of 40-86, and the fifth well (64-88BR) will be constructed south of 31-87BR

Sandstones O, N, and M were encountered in well 40-86 This well is completed in Sandstone P, and volatile organics have been detected in well 40-86 To delineate the vertical extent of volatile organics were detected in well 40-86, one bedrock well (70-88BR) will be completed in the underlying sand unit (Sandstone O), and another well (81-88BR) will be installed in the overlying sand unit (Sandstone M) adjacent to well 40-86 In addition, three wells (69-88BR, 71-88BR, and 68-88BR) will be installed in Sandstone N to evaluate the extent of volatile organics in ground water

4 4 SURFACE WATER AND SEDIMENT CHARACTERIZATION

Nineteen surface water stations were established south of the 903 Pad and East Trenches Areas in the Woman Creek drainage during the 1986 and 1987 investigations, and seven stations were established north of the Mound and East Trenches Areas in the South Walnut Creek drainage These 26 stations, along with three additional (SW-101, SW-102, and SW-103) seeps north of the Mound and East Trenches Areas, will also be sampled during the Phase II RI investigation Plate 4-1 presents surface water monitoring locations at Rocky Flats Plant, and Table 4-7 presents the surface water stations to be sampled during the Phase II RI

Sediment samples will be collected from surface water stations located along South Walnut Creek, Woman Creek, and the South Interceptor Ditch Sediment sampling locations are also indicated on Table 4-7

TABLE 4-7
SURFACE WATER AND SEDIMENT SAMPLING STATIONS

SW-1 *
SW-26*
SW-27*
SW-28*
SW-29*
SW-30*
SW-50
SW-51
SW-52
SW-53
SW-54*
SW-55
SW-56
SW-57
SW-58
SW-59
SW-60*
SW-61
SW-62*
SW-63
SW-64*
SW-65
SW-101
SW-102
SW-103

*Sediment samples will be collected at these surface water stations locations

5 0 METHODS

5 1 SAMPLING AND DATA COLLECTION METHODS

Field sampling and data collection will follow the Standard Operating Procedures (SOPs) as well as data management requirements set forth in the Technical Data Management (TDM) Plan Presented below are discussions of data collection methods being utilized in the Phase II RI

5 1 1 Surficial Soil Sampling

Soil samples for plutonium-239 and americium-241 will be collected from 54 10-acre plots near the 903 Pad, Mound, and East Trenches Areas and in the buffer zone to Indiana Street following Colorado Department of Health sampling protocol In addition, vertical profiles of plutonium and americium will be developed at 24 randomly located sites in the same general area Surficial samples will be collected at these locations using plant standard, CDH, and EPA protocols so that data are available to address the standards of each Samples will be collected every 50 to 100 centimeters to a depth of one meter in order to evaluate the vertical distribution of plutonium and americium

5 1 2 Borehole Soil Sampling

Soil samples will be collected from boreholes within and adjacent to SWMUs to characterize sources and assess the extent of soil contamination All samples will be analyzed for the parameters listed in Table 5-1 following contract laboratory procedures (CLP) or the methods specified in the QA/QC plan These parameters are

TABLE 5-1

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

METALS

Hazardous Substance List - Metals

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Chromium (hexavalent)
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Tin
- Vanadium
- Zinc

TABLE 5-1 (CONTINUED)

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

ORGANICS

Hazardous Substances List - Volatiles
- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

TABLE 5-1 (CONTINUED)

SOURCE SAMPLING PARAMETERS
SOIL AND WASTE SAMPLES

RADIONUCLIDES

Gross Alpha
Gross Beta
Uranium 233+234, 235 and 238
Americium 241
Plutonium 239+240
Tritium

the same as those analyzed in the Phase I RI except that oil and grease, RCRA characteristics, semi-volatile organics, pesticides, and PCBs are eliminated Oil and grease have not proven useful in determining extent of soil contamination, and RCRA hazardous waste characteristics have been within acceptable limits

Soil samples will be collected every two feet from ground surface into bedrock The samples will be composited over the two-foot interval and every other sample submitted for analysis, including a bedrock sample from each borehole A complete soil sample will consist of five jars, as follows

- two 4-ounce clear glass jars for volatile organics,
- two 8-ounce clear glass jars for metals and inorganics, and
- one 8-ounce clear glass jars for radiochemistry

5 1 3 Drilling and Logging

All boreholes for soil sampling and monitor well construction will be continuously sampled to the extent drilling conditions permit and geologically logged Hollow stem augers will be used to advance boreholes through surficial materials and weathered bedrock, and materials will be continuously sampled through the augers with split tube samplers Unweathered bedrock will be rotary drilled and continuously cored (size NX) All lithologic samples will be labeled, described, and packaged by a geologist in the field as described in the SOPs

5 1 4 Monitor Well Installation

Three types of monitor wells will be constructed in the Phase II RI Monitor well construction methods will be consistent with those used in the Phase I RI The wells will be completed with four-inch diameter PVC casing The slotted interval will consist of PVC casing with 0 01-inch machine-cut slots, and 16-40 silica sand will be placed in the annulus around the screened interval The sand pack will not extend more than two feet above the top of the screen

Any space beneath the screen will be backfilled with bentonite pellets before well construction, and a bentonite pellet seal will be placed over the sand pack Neat cement grout will be tremied to the surface above the bentonite seal, and protective casing will be placed over the well at the surface A locking cap will be installed on the protective cap, and a three foot by three foot concrete pad will be poured around the protective casing to finish the well

5 1 4 1 Alluvial Wells

Wells completed in surficial materials (alluvial wells) will be cased with Schedule 40 PVC The wells will be screened from the top of bedrock to within three feet of ground surface if the subsurface materials are relatively homogeneous and a perched water-bearing zone is not encountered The sand pack will extend 0 5 feet above the screened interval, and a 0 5 feet thick bentonite seal will be placed over the sand pack (Figure 5-1) Neat cement grout will be tremied to the surface if the cement thickness is greater than ten feet (grout will be poured to the surface if the thickness is ten feet or less) and protective casing will be placed over the well

If a clay lens greater than one foot in thickness is encountered in the hole and there is water above the clay, the well will be screened above the clay A second well will be installed below the clay layer to evaluate vertical ground-water movement and water quality variations in surficial materials The screened interval of the deeper well will stop at least two feet below the base of the clay lens so that six inches of

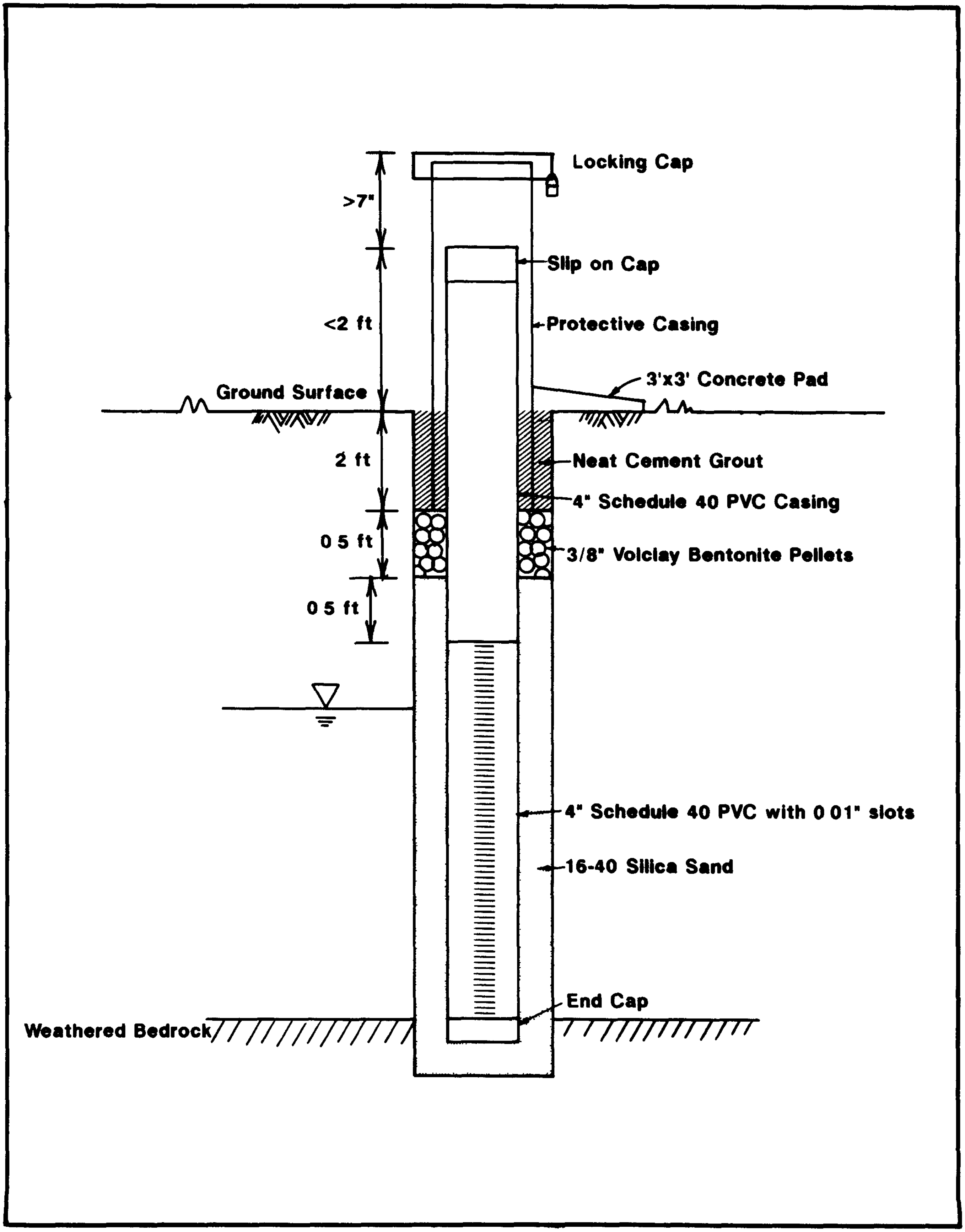


Figure 5-1 ALLUVIAL MONITOR WELL CONSTRUCTION

sand above the screen and two feet of bentonite pellets above the sand can be placed and still provide at least 1 5 feet of seal below the clay lens

5 1 4 2 Shallow Bedrock Wells

Shallow bedrock wells will be augered to total depth using large diameter hollow stem augers and constructed through the augers, because many of the wells will be completed in poorly consolidated (running) sandstones The wells will be screened to within 0 5 feet of the top of the sandstone, and the sand pack will extend 0 5 feet above the screened interval (Figure 5-2) Sand pack will not extend above the top of the sandstone A two-foot bentonite seal will be placed over the sand pack Neat cement grout will be tremied to the surface if the cement thickness is greater than ten feet (grout will be poured to the surface if the thickness is ten feet or less), and protective casing will be placed over the well

5 1 4 3 Deep Bedrock Wells

Deep bedrock wells to be completed in unweathered, consolidated sandstones will be drilled in two stages The hole will first be advanced through surficial materials and weathered bedrock using hollow stem augers Steel casing will then be installed in the hole and grouted to the surface (Figure 5-3) The remainder of the hole will then be rotary cored to total depth and then reamed to seven inch diameter or greater The monitor well screened interval, sand pack, bentonite seal, cement seal, and protective casing will be installed as for shallow bedrock wells, except that Schedule 80 PVC casing and screen will be used

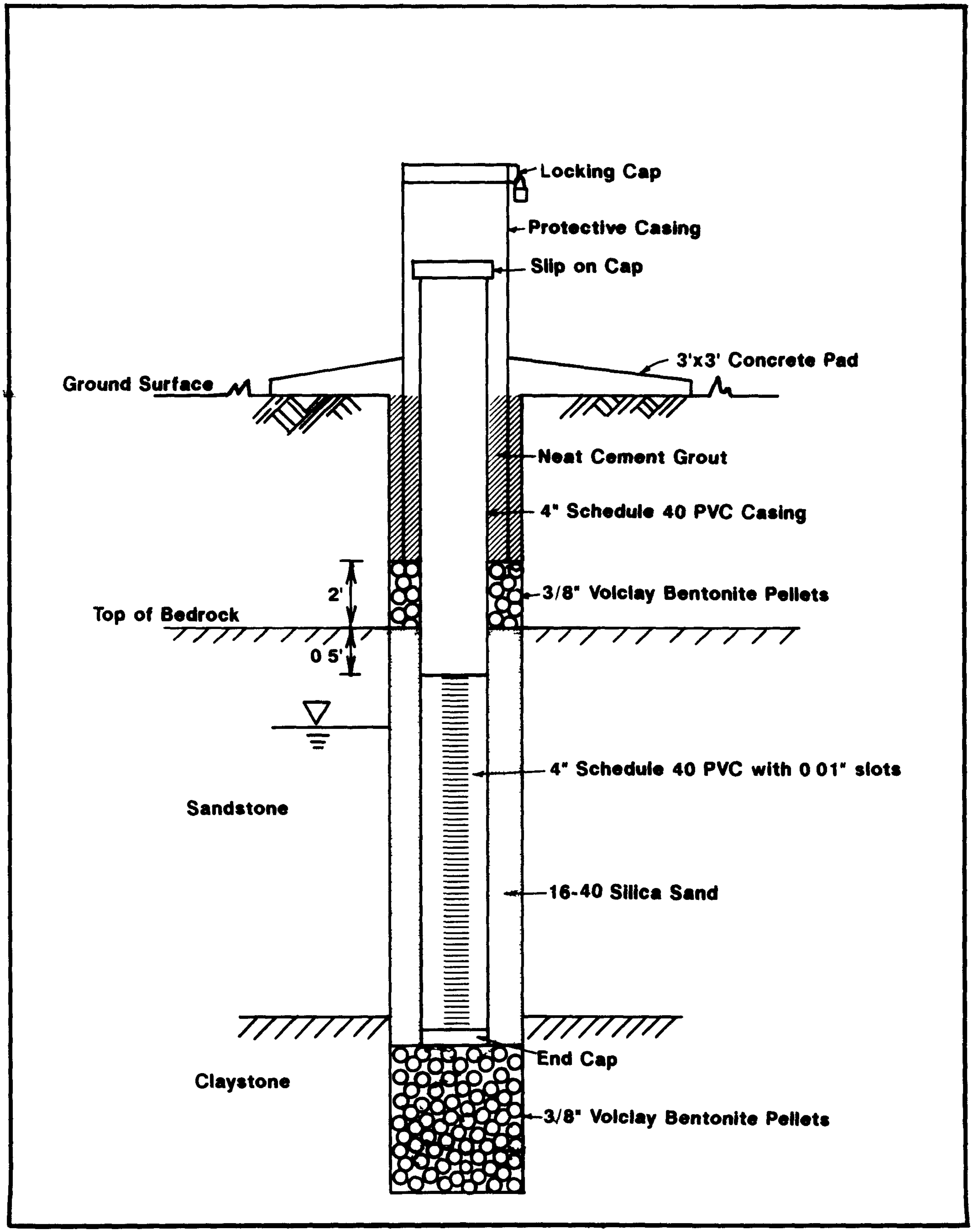


Figure 5-2: SHALLOW BEDROCK WELL CONSTRUCTION

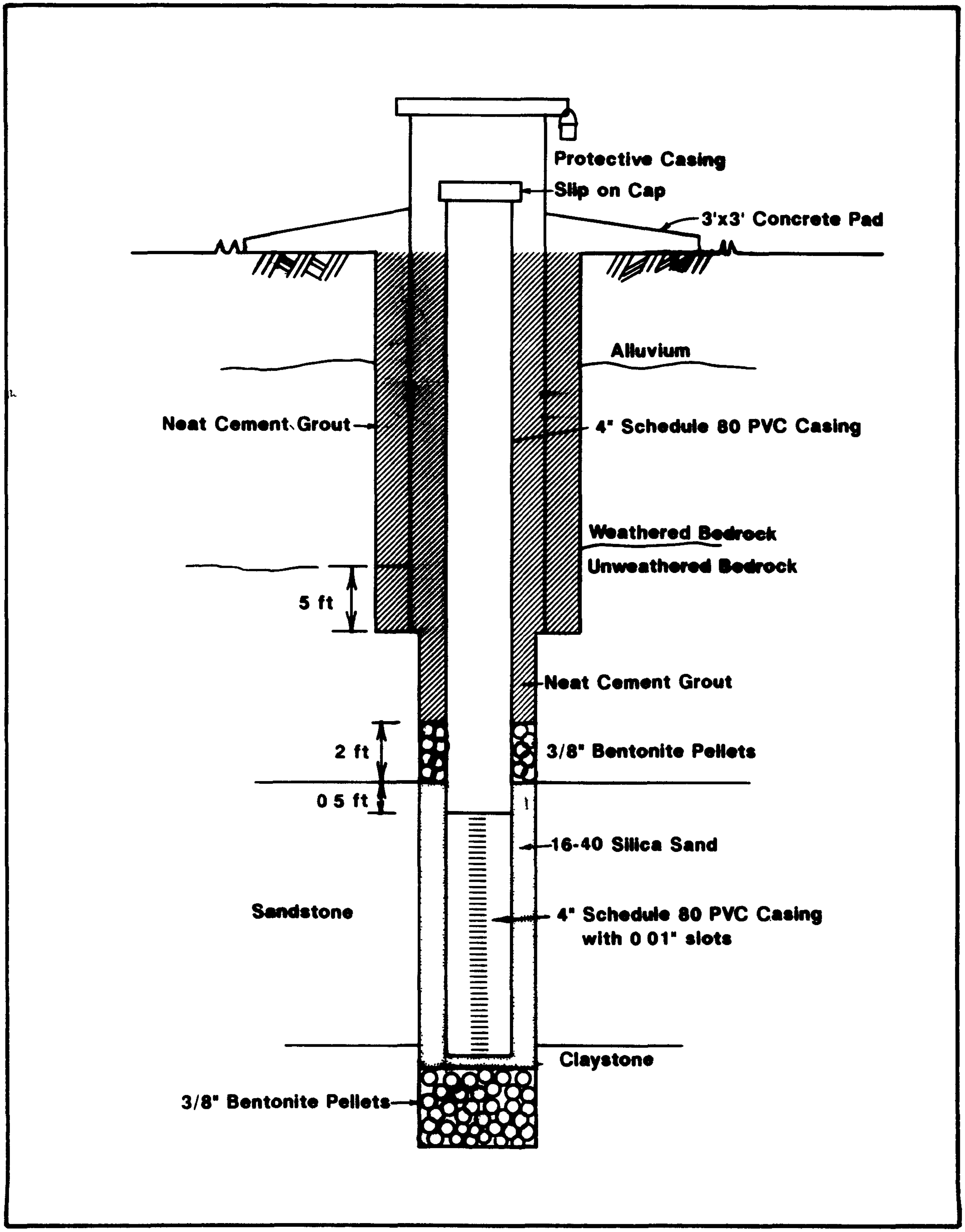


Figure 5-3: DEEP BEDROCK MONITOR WELL CONSTRUCTION

5 1 5 Well Development

The wells will be developed by bailing, surging, or airlifting no sooner than 24 hours after placement of the surface concrete but before the wells are sampled or tested

5 1 6 Ground-Water Sampling

Ground-water samples will be collected from the 76 new monitor wells and the 40 existing wells at the 903 Pad, Mound, and East Trenches Areas (Plate 2-3) Sampling will be performed in accordance with the SOPs

Ground-water samples will be analyzed in the field for pH, conductivity, and temperature With the exception of samples designated for volatile organic analyses, all samples will be filtered and preserved in the field Volatile organic samples will not be filtered Samples will be analyzed for the parameters listed in Table 5-2

5 1 7 Hydraulic Tests

Slug tests will be performed on all new and existing wells to evaluate the horizontal hydraulic conductivities of the various materials In addition, pumping tests will be performed in selected wells to evaluate the hydraulic continuity of sandstone horizons The tests will follow well development and ground-water sampling Hydraulic test methods and data analysis will follow the project SOPs

TABLE 5-2
GROUND-WATER SAMPLING PARAMETERS

FIELD PARAMETERS

pH
Specific Conductance
Temperature

INDICATORS

Total Dissolved Solids

DISSOLVED METALS

Hazardous Substances List - Metals
Chromium (hexavalent)
Lithium
Strontium
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Tin
Vanadium
Zinc

ANIONS

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate as N

TABLE 5-2 (CONTINUED)
GROUND-WATER SAMPLING PARAMETERS

FIELD PARAMETERS

ORGANICS

Hazardous Substances List - Volatiles

- Oil and Grease
- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

RADIONUCLIDES

- Gross Alpha
- Gross Beta
- Uranium 233+234, 235, and 238
- Americium 241
- Plutonium 239+240
- Tritium

5 1 8 Water Level Measurements

Water levels will be measured monthly in all new and existing wells subsequent to well development These measurements are needed to evaluate seasonal variability in water levels and extent of saturation Water level measurements will follow the SOPs

5 1 9 Surface Water and Sediment Sampling

Surface water and sediment samples will be collected from the stations downstream of the 903 Pad, Mound, and East Trenches Areas to characterize surface water quality Flow rates will be measured at each monitoring location at the time of sample collection and monthly thereafter for the duration of the RI field program to evaluate seasonal variability in flow rates

Surface water samples will be analyzed in the field for pH, conductivity, temperature, and dissolved oxygen Laboratory analyses of surface water samples will consist of the parameters listed in Table 5-3, and sediments will be analyzed for the parameters listed in Table 5-1 All samples requiring filtration will be filtered in the field, and all samples will be preserved in the field Surface water sampling and stream flow measurements will follow the procedures described in the SOPs

5 2 LABORATORY ANALYSIS METHODS

Laboratory analyses of soil, ground-water, and surface water samples will be performed following CLP protocols Details of the laboratory analysis program are presented in the Quality Assurance/Quality Control Plan

TABLE 5-3

SURFACE WATER SAMPLING PARAMETERS

FIELD PARAMETERS
pH
Specific Conductance
Temperature
Dissolved Oxygen

INDICATORS
Total Dissolved Solids
Total Suspended Solids

METALS (Filtered and Unfiltered)
Hazardous Substances List - Metals
Chromium (hexavalent)
Chromium (trivalent)
Lithium
Strontium
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Tin
Vanadium
Zinc

TABLE 5-3 (Continued)

SURFACE WATER SAMPLING PARAMETERS

ANIONS (Unfiltered)
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate as N

ORGANICS (Unfiltered)
Hazardous Substances List - Volatiles
Oil and Grease
Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon Tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
2-Chloroethyl Vinyl Ether
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

TABLE 5-3 (Continued)

SURFACE WATER SAMPLING PARAMETERS

RADIONUCLIDES
Gross Alpha (Filtered)
Gross Beta (Filtered)
Uranium 233+ 234, 235, and 238
(Filtered and Unfiltered)
Americium 241
(Filtered and Unfiltered)
Plutonium 239+240
(Filtered and Unfiltered)
Tritium (Unfiltered)

5 3 DATA ANALYSIS METHODS

5 3 1 Data Acceptance

Several criteria will be used to judge the acceptability of the data These include

- sufficiency of data reporting,
- presence and sufficient documentation of QA/QC,
- presence and documentation of custody,
- validity of sampling and analysis methodology, and
- conceptual validity

These criteria will be applied to the data through implementation of the QA/QC Plan and the Data Management Plan

The final step in the acceptance process will be to evaluate the validity of the data with respect to the conceptual model of the site If the data contradict the conceptual model, one of the following conclusions will be drawn

- find the review data unacceptable, based on the overwhelming evidence of other accepted data,
- additional data will be necessary to clarify ambiguities in the conceptual model, or
- the conceptual model must be changed based on the data under review, which must constitute overwhelming evidence against the data used to formulate the previous conceptual model

Dixon's Test for outliers (Dixon, 1953) will be used to determine if the data are unacceptable based on the overwhelming evidence of other accepted data An outlier is an extreme observation that does not conform to the pattern established by other observations The outlier may be a result of an incorrectly read, recorded, or transcribed measurement, an incorrect calculation, or an error in field documentation for a sample Outliers are minimized by strict adherence to the QA/QC and TDM Plans However, should it be determined that there is no assignable cause for the outlier, Dixon's Test, a statistical procedure for determining the probability the datum would be observed if the data were normally distributed, will be used Dixon's Test computes the fraction of the range between the datum and the nearest data point and the entire range of the data set This fraction is compared to the test criterion, r The entire data set is first ordered from highest to lowest assigning X_1 to the highest value and X_N to the lowest value For less than eight measurements (typical of the Rocky Flats data base), reject X_N if

$$\frac{X_N - X_{N-1}}{X_N - X_1} > r$$

Critical values for r at the 95% confidence level are shown below

Number of Measurements	r
3	941
4	765
5	642
6	560
7	507

Dixon's test can result in false negatives (an outlier is not identified) if there are two (2) high or low outliers, however, the test is applicable to small data sets When 25 or more data points are available, an alternate test for outliers may be used, such as Rosner's method that is not sensitive to masking by multiple outliers (Gilvert, 1987)

A related issue regarding data acceptance is the validity of HSL organic data for a sample given the occurrence of HSL organics in the laboratory blanks Standard CLP protocols (EPA, 1986) will be used as follows

1 Verify that the reagent blank analysis(es) contain less than the Contract Required Detection Limits (CRDL) of any HSL compound, (5 X CRDL) for the following specific compounds

   a Methylene chloride
   b Acetone
   c Toluene
   d Common phthalate esters

2 No positive results will be accepted unless the concentration of the compound in the sample exceeds 10 times the amount in any blank for the common contaminants listed above or 5 times the amount for other compounds The results will not be corrected by subtracting the blank value Specific actions are as follows

   a If common contaminant compounds are detected in samples at a concentration of less than 10 times the concentration found in the blank, or other compounds at less than 5 times the concentration in the blank, these compounds will be reported as not detected The sample quantitation limit will be adjusted to the value reported in the sample and the limit flagged as estimated (UJ)

   b If gross contamination exists (i e, saturated peaks by GC/MS), all compounds affected will be reported as unusable (R) due to interference in all samples affected

The same procedure will be applied if the compound is detected in the applicable field blank

5 3 2 Data Interpretation

Data from the Phase II RI investigation will be incorporated into the existing data base and used to better define the extent of contamination and the pathways for contaminant migration Data will be incorporated into maps and cross sections defining the geology, hydrogeology, and extent of contaminant plumes

Borehole geologic data will be used to refine the bedrock surface map and paleochannels, the extent and orientation of sandstone units in the Arapahoe Formation, and areas of subcropping sandstones Soil chemical data will be used to better define contamination in the vicinity of waste sources

Chemical and geohydrologic data will be used to define the approximate boundaries of contaminant plumes and their rate of migration Horizontal and vertical flow patterns, including seasonal effects, will be reevaluated based on the new data Gross transport characteristics of select contaminants will be used to estimate contaminant migration and provide the basis for developing remedial alternatives for contaminated ground water

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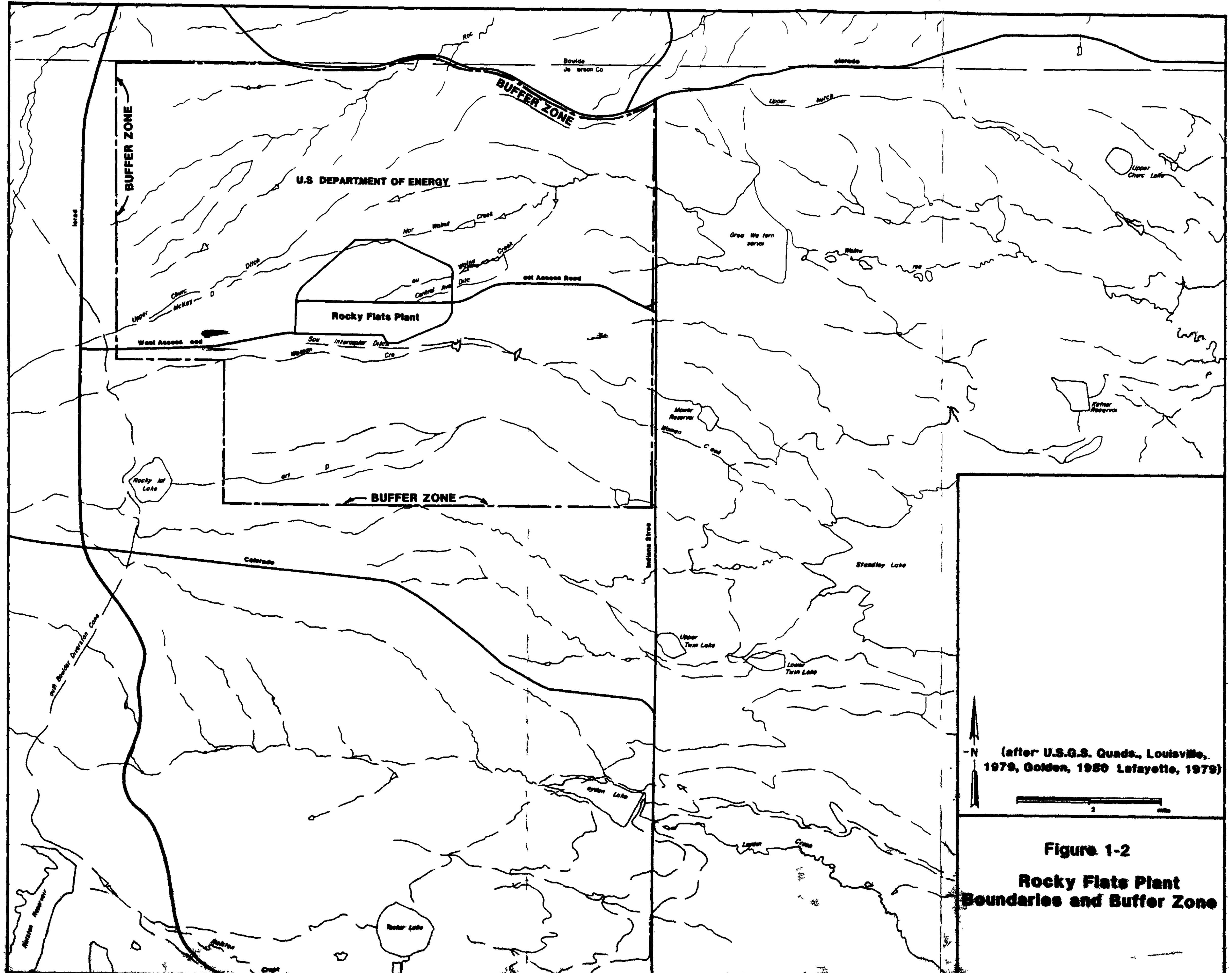

Figure 1-2

Rocky Flats Plant Boundaries and Buffer Zone

EXPLANATION

- [box] Location of Solid Waste Management Unit
- [dashed box] Location of Areas of Interest Within Solid Waste Management Unit
- 101 Solid Waste Management Unit Reference Number (Rockwell International 1986a)

NOTES

1) Base map photo enlarged from aerial photography of Rocky Flats Plant taken May 20 1986

2) The locations of the solid waste management units have been located as accurately as possible based on information available prior to 1987 remedial investigation

Modifications to these locations as a result of on going studies and future site characterization will be made as required

1 = 500

0 500 1000

Figure 1 4
Remedial Investigation Area Locations and Associated Solid Waste Management Units